WIN-SA
WATER INFORMATION NETWORK - SOUTH AFRICA -

FSM2

2nd International Faecal Sludge Management Conference

International Convention Centre, Durban, South Africa
29 - 31 October 2012

WATER RESEARCH COMMISSION

CONFERENCE REPORT

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The **FSM2 Conference Report** has been produced for **Water Information Network - South Africa (WIN-SA)** and the **Water Research Commission (WRC)** by **Idube Media**. The report is based on information made available at the FSM2 conference, including individual abstracts and presentations. This report has been reviewed by the WRC and WIN-SA and approved for publication.

Abbreviations

AD	Anaerobic Digestion
AIT	Asian Institute of Technology
AnMBR	Anaerobic Membrane Bioreactor
BMGF	Bill and Melinda Gates Foundation
CEWAS	Centre for Water Management Services
Cirus	Centre for Innovation Research in Utility Sectors
CLTBCHS	Community Led Total Behaviour Change in Hygiene and Sanitation
DEWATS	Decentralised waste water treatment systems
DWA	Department of Water Affairs
Eawag	Swiss Federal Institute of Aquatic Science & Technology
ECBP	Government of Ethiopia Engineering Capacity Building Program
ETHZ	Swiss Federal Institute of Science and Technology Zurich
EWS	eThekwini Water and Sanitation
FSM	Faecal Sludge Management
GCE	Gates Foundation Grand Challenges Explorations
GIZ	GIZ Deutsche GesellschaftfürInternationaleZusammenarbeit
IFAK	Institutfür Automation und Kommunikation
IWMI	International Water Management Institute
LaDePa	Latrine Dehydration Pasteurisation
LWSC	Lusaka Water and Sewerage Company
MEC	Microbial Electrolysis Cell
MFC	Microbial Fuel Cell
NSSMP	National Sewerage and Septage Management Program
OSS	Onsite Sanitation Systems
PSA	Pit Sludge Auger
PRG	Pollution Research Group
PV	Photovoltaic-powered
RRR	Resource Recovery and Reuse
RTTC 2	Reinvent the Toilet Challenge
Sandec	Department of Water & Sanitation in Developing Countries
SERD	School of Environment, Resources and Development
SOIL	Sustainable Organic Integrated Livelihoods
SSIP	Small-scale independent providers
SSP	Sanitation Safety Plans
SuSanA	Sustainable Sanitation Alliance
Swiss THP	Swiss Tropical and Public Health Institute
UDDT	Urine Diverting Dry Toilets
UF	Ultra Filtration
UKZN	University of KwaZulu-Natal
UV	Ultraviolet
VIP	Ventilated Improved Pit-latrine
VUNA	Valorisation of Urine Nutrients in Africa
WASAZA	Water and Sanitation Association of Zambia
WHO	World Health Organization
WRC	Water Research Commission
WSA	Water and Sanitation for Africa
WSUP	Water and Sanitation for the Urban Poor

Second International Faecal Sludge Management Conference

In March 2011, the first Faecal Sludge Management Seminar was held in Durban, South Africa taking place over two days. With the theme: *What Happens when the Pit is Full? Developments in on-site Faecal Sludge Management,* the seminar was attended by 120 local and international delegates from four continents. Delegates included: local government, NGOs, research organisations and academia. This first FSM seminar was backed by the Stockholm Environment Institute (SEI), South African Local Government Association (SALGA), Irish Aid and the Water Research Commission. FSM1 comprised 16 presentations from invited speakers.

The Second International Faecal Sludge Management Conference was held in Durban from the 29th to the 31st of October 2012. Attended by some 320 delegates from around the world, including policy makers, scientists, innovators, representing more than 30 countries and five continents who gathered to share ideas and discuss the challenges and opportunities in the business of on-site sanitation.

The conference was held over three days and comprised, more than 90 presentations covering a wide range of topics.

The opening session of the conference, included a line-up of the following keynote speakers:

Dr Doulaye Koné – Senior Programme Officer, Bill and Melinda Gates Foundation
The BMGF has committed over $200Million over the next few years to research and advocacy in this field which it has identified as a major area for impacting health in the developing world.

Dr Linda Strande – Research Manager, EAWAG
EAWAG is a leader in the FSM field, and manages research projects around the world. The organisation is currently compiling a book on the subject of Faecal Sludge Management.

Steve Sugden – Research Manager, Water for People and the London School of Hygiene and Tropical Medicine, looked at sanitation as a business, drawing on his experiences with the development and transfer of the Gulper technology into commercial businesses – giving valuable insight into the process of taking a technology from concept into the marketplace.

Pam Elardo, Director of the Wastewater Treatment Division in the Department of Natural Resources and Parks, King County, Washington, presented a case study entitled Reimagining Sanitation in Seattle.

Field visits were arranged following the day after the conference and included the following sites:
- LaDePa (Latrine Dehydration and Pasteurisation plant) – pelletising of pit sludge
- The eThekwini Pit emptying programme
- Struvite generation from urine plant at the University of KwaZulu Natal
- The Newlands/kwaMashu permaculture centre and ABR research facility
- eThekwini's informal settlement sanitation provision programme

FSM 2 was backed by a number of leading international organisations, including representatives from the Bill and Melinda Gates Foundation, International Water Association (IWA), Irish Aid – Government of Ireland, Water and Sanitation for all in Africa (WSA). Local companies and organisations backing the conference included: Conloo (a division of Conrite Walls (Pty) Ltd), Department of Science and Technology (DST), Envirosan Sanitation Solutions, eThekwini Metropolitan Municipality, San Africa Precast, University of KwaZulu-Natal and Water Research Commission (WRC). The organising committee of the FSM2 Conference take this opportunity to thank these organisations for their contribution and support. A special thanks goes to the event organiser Partners in Development (PID).

Millennium Development Goals, Target 7C is to: *Halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation.* Access to improved sanitation facilities increased from 36 per cent in 1990 to 56 per cent in 2010 in the developing regions as a whole. However, despite progress, 2.5 billion in developing countries still lack access to improved sanitation facilities.

FSM2 provided an insight into the latest research, technological advancements and solutions to the world's sanitation challenges.

Conference programme

Monday, 29 October 2012 (DAY 1)

8h00 Registration

Opening Session (P1) Chair: Dhesigen Naidoo

9h00 Dhesigen Naidoo, CEO, Water Research Commission of South Africa Welcome

9h10 Neil Macleod, Head, Ethekwini Water and Sanitation (City of Durban) Durban Looking beyond conventional sanitation solutions

09h35 Doulaye Kone, Senior Programme Officer, Global Development, BMGF. An overview of the FSM work of the Bill and Melinda Gates Foundation

10h00 Steve Sugden, Water for People/London School of Tropical Health and Hygiene Reflections on business models and technology designs for pit emptying services

10h25 Questions and Discussion

10h40 Tea

	Session A1: Main Hall Chair: Kevin Wall	**Session B1: Breakaway 1 Chair: Stephen Mecca**	**Session C1: Breakaway 2 Chair: Elizabeth von Muench**
11h10	WaterAid Bangladesh Aftab, Opel Challenge critical: Absence of FSM shatters the gains of improved sanitation coverage in Bangladesh	University College London UK Campos, Luiza Simulating nutrient and energy fluxes in non-networked sanitation systems	University of KwaZulu-Natal South Africa Buckley, Chris An overview of FSM research in Durban
11h35	Water&Sanitation Programme: World Bank, Indonesia Blackett, Isabel Indonesia: Development of urban septage management models	Sustainable Sanitation Design Norway Gjefle, Karsten The sustainable sanitation design concept for sludge treatment for cities in Africa	University of KwaZulu-Natal South Africa Foxon, Kitty How fast do pits fill up? Empirical evidence and mathematical models
12h00	EAWAG-SANDEC, Switzerland Schoebitz, Lars Business Model Innovations for Scaling-up FSM Businesses in Low- and Middle-income Countries	Chinese Academy of Sciences China Fan, Bin Vacuum source-separation eco-san and decentralized wastewater management in China	Asian Institute of Technology Thailand Koottatep, Thammarat Accumulation rates of thickened-bottom sludge and its characteristics from water-based onsite sanitation systems in Thailand
12h25	WSA Burkina Faso Yofe, JeanMarc Impact of prices and tariffs on FSM in Africa	Rural Water Supply and Sanitation Project in W. Nepal Goudel, Chhabi Lal Investing in people – using human shit and urine as organic fertilizer, energy saver and for economic development in vulnerable communities of Nepal	WRC South Africa Bhagwan, Jay Pour flush – a new sanitation paradigm in Africa, and implications for FSM

12h50 Lunch

	Session A2: Main Hall Chair: Linda Strande	**Session B2: Breakaway 1 Chair: Alyse Schrecongost**	**Session C2: Breakaway 2 Chair: Yu-Ling Cheng**
14h00	University of Toulouse, GRET France Frenoux, Clément Domestic private FS emptying services in Cambodia: between market efficiency and regulation needs for sustainable mgmt	Duke University USA Mazibuko, Mandisa A waterless toilet with electrochemical disinfection and biomass combustion	University of Rochester USA Guo, Chunlei Superhydrophobic materials for FSM
14h25	RTI International, USA Robbins, David Best practices in Faecal sludge management – lessons learned from four case studies in the Philippines	Swedish University of Agricultural Sciences Vinnerås, Björn Sanitation of faecal sludge by ammonia	University of Delaware USA Dentel, Steven Breathable membrane enclosures for faecal sludge stabilization
14h50	Biome Environmental Trust India Srikantaiah, Vishwanath The informal sector in faecal sludge management – a perspective from India	University of California, Berkeley, USA Ogunyoku, Temitope The disinfection of latrine faecal sludge with ammonia naturally present in excreta	Cranfield University UK Parker, Alison The nano membrane toilet

15h15 Tea

	Session A3: Main Hall Chair: Stephen Sugden	Session B3: Breakaway 1 Chair: Marc Deshusses	Session C3: Breakaway 2 Chair: Oliver Ive
15h45	Water and Sanitation for the Urban Poor (WSUP), UK Narracott, Andy The Uniloo approach to sanitation in Kumasi, Ghana	Washington University USA Tang, Yinjie Metabolic engineering of microbial platforms to convert anaerobic digestion wastes to biofuel	Swedish University of Agricultural Sciences Lalander, Cecilia The potential of treating human faeces with black soldier fly larvae
16h10	Loowatt UK Purves, Iain Financially and culturally sustainable applications of Loowatt technology in Antananarivo, Madagascar – early feedback	Oklahoma State University USA Foutch, Gary Treatment of faeces by viscous heating	EAWAG Switzerland Larsen, Tove Diversion for safe sanitation: a new approach to sanitation in informal settlements
16h35	Laam Science, Inc USA Schneider, Josef Reinventing the toilet – a simple, inexpensive solution- multi-use collection bag	Delft University Netherlands Talsma, Laura The proposal of plasma gasification for an off the grid sanitation solution	Fundación In Terris Ecuador Fioravanti, Marcos The earth auger toilet: Innovation in waterless sanitation

Tuesday, 30 October 2012 (DAY 2)

Plenary Session (P2) Chair: Doulaye Kone

08h30	Linda Strande, Programme Leader of Excreta and Wastewater Management, EAWAG/SANDEC Managing Your Everyday Shit: Systems Approach for Faecal Sludge Management
08h55	Pam Elardo, Director, Wastewater Treatment Division, Seattle Evolution of a regional wastewater management system: matching decisions to capacity
09h20	Glenn Pearce-Oroz, Regional Team Leader, World Bank - Water and Sanitation Program, Peru Living without Sanitary Sewers in Latin America
09h55	Thor-Axel Stenström, Swedish Institute for Infectious Disease Control Health and exposure assessments as tools for faecal sludge management

10h20 Tea

	Session A4: Main Hall Chair: Valerie Naidoo	Session B4: Breakaway 1 Chair: Tove Larsen	Session C4: Breakaway 2 Chair: Bjorn Vinneras
10h50	California Institute of Technology, USA Cid, Clément Solar-powered approaches to human wastewater and sludge treatment	University of Eastern Finland Finland Pradhan, Surendra Urine fertilizer for vegetable production – a case study in Nepal	Columbia University USA Chandran, Kartik Resource recovery from faecal sludge – an elemental approach
11h15	University of Colorado USA Summers, Scott Solar-driven thermal toilet with biochar production	EAWAG Switzerland Udert, Kai VUNA: Nutrient harvesting from urine	San Diego State University USA Garoma, Temesgen Enhanced anaerobic digestion as a sanitation and energy recovery technology
11h40	Beijing Sunnybreeze Technologies, China Ning, Jing Faecal sludge disposal in situ- a solar toilet solution for dry countries/sunny zone(Cancelled)	University of KwaZulu-Natal, South Africa Benoit, Natalie Individuals' perception & the potential of urine in agriculture in eThekwini, South Africa	Duke University USA Deshusses, Marc Effective sewage sanitation with low CO2 footprint
12h05	Sanivation, Georgia Institute of Technology, USA Woods, Emily Inactivation of helminth in a solar concentrator	NADEL Switzerland Tilley, Elizabeth Incentivising sanitation through urine collection	Frontier Environmental Technology USA Canter, Tim Self-mixing biogas generator

12h30	University of Toronto Canada Cheng, Yu-ling A unit operations approach for rapid disinfection of human waste based on drying/smoldering of solid and sand filtration/uv disinfection of liquid waste	Cape Peninsula U. of Technology South Africa Muanda, Christophe Management of FS from a mobile communal sanitation facility – a case study of the MobiSan	Alianza para la Innovación en Integridad de Infraestructura y Ductos, Mexico De Silva Muñoz Conversion of faecal sludge to liquid fuels. Why and how could it work for small-scale applications
12h55	Lunch		
	Session A5: Main Hall Chair: Gary Foutch	**Session B5: Breakaway 1 Chair: Vanniasingham Baghiratan**	**Session C5: Breakaway 2 Chair: Kartik Chandran**
14h00	Plymouth Marine Laboratory UK Allen, Mike Vortex bioreactors for the processing of FS and waste water in decentralized waste water treatment systems	Arba Minch University Ethiopia Dalecha, Teshale Experiments on struvite precipitation, application and economic analysis in Arba Minch, Ethiopia	Texas A&M University USA Han, Arum Highly efficient microbe-mediated energy harvesting from wastewater through nanomaterial decorated three-dimensional multi-length scale porous matrix electrode
14h25	University of South Florida USA Yeh, Daniel NEWgeneratorTM membrane biotechnology for the recovery of nutrients, energy and water from human wastes	University of KwaZulu-Natal South Africa Grau, Maximilian Nutrient recovery from urine: operation and optimization of reactors in eThekwini	Arizona State University USA Rogers, Brad Decentralized organic and nitrogen removal from domestic waste in rural Ghana with a microbial fuel cell
14h50	Eram Scientific Solutions India Baby, Bincy Research on self-sustained e toilet for households /urban-semi urban public / community sanitation	EAWAG Switzerland Hug, Thomas Model-based performance evaluation of the collection of source-separated urine	U. of the West of England and U. of Bristol, UK Ieropoulos, Ioannis Energy production and sanitation improvement using microbial fuel cells
15h15	Tea		
	Session A6: Main Hall Chair: Thammaret Koottatep	**Session B6: Breakaway 1 Chair: Elizabeth Tilley**	**Session C6: Breakaway 2 Chair: John Harrison**
15h45	Providence College USA Mecca, Stephen The microflush/biofil system: results to date of prototype installations in Ghana	Partners in Development South Africa Louton, Bobbie Pit emptying and public health	WSA Burkina Faso Ujah, Oliver Ethics and FSM in Africa
16h10	Wetlands Work! Conservation Int'l Cambodia Chakraborty, Irina Floating treatment pods for lake communities	University of Eastern Africa Kenya Maradufu, Asafu Using senecio lyratipartitus extracts as hand disinfectants after anal ablution	Water Research Commission South Africa Naidoo, Valerie The CLARA project – capacity-linked water supply and sanitation improvement for Africa's peri-urban and rural areas
16h35	Salt Lake City USA Larsen, Andrew Five-toilet composting system array in peri-urban slums in Haiti -a report on progress	Swiss Tropical and Public Health Institute Cissé, Guéladio Sanitation Safety Plans for Safe Management of Faecal Sludge	GIZ Germany von Muench, Elisabeth Accelerating learning in sustainable sanitation

Wednesday, 31 October 2012 (DAY 3)

	Session A7: Main Hall Chair: Nick Alcock	**Session B7: Breakaway 1 Chair: Kitty Foxon**	**Session C7:Breakaway 2 Chair: Isabel Blackett**
8h30	Sustainable Organic Integrated Livelihoods, Haiti Preneta, Nick Thermophilic co-composting of human wastes from urine diversion toilets in Haiti	University of Loughborough UK Martin, Simon A toilet system based on hydrothermal carbonization	Partners in Development South Africa Still, David In search of the ideal pit emptying technology

Conference programme

9h05	Hamburg University of Technology, Germany Bulbo, Mammo Co-composting of faecal matter with bio-char	The Climate Foundation USA Von Herzen, Brian Thermal processing of solid waste to biochar in urban settings	eThekwini Municipality South Africa Wilson, Dave Pit emptying in eThekwini (Durban)
9h30	International Water Management Institute, Ghana Nikiema, Josiane Fortified excreta pellets for agriculture	re:char USA Aramburu, Jason Human excreta to energy and biochar in urban Kenya	Council for Scientific and Industrial Research, South Africa Wall, Kevin Social franchising principles do work: The business approach to removal and disposal of faecal sludge - from pilot to scale
9h55	eThekwini Water and Sanitation South Africa Harrison, John Towards sustainable pit latrine management in South Africa through the LaDePa pelletising machine	University of KwaZulu-Natal South Africa Cottingham, Ruth Velkushanova, Tina Reinventing the toilet at UKZN and Properties of Faecal Sludge	Impilo Yabantu South Africa Ive, Oliver Demonstrating the effectiveness of social franchising principles: the emptying of household VIPs
10h20	Tea		
	Session A8: Main Hall Chair: Dave Wilson	**Session B8: Breakaway 1 Chair: Tina Velkushanova**	**Session C8:Breakaway 2 Chair: Peter Hawkins**
10h50	Partners in Development South Africa Still, David Beneficial use of faecal sludge through deep row entrenchment	Water Reform Programme, GIZ Germany Blume, Steffen Faecal sludge management of decentralised treatment systems in Zambia	SANDEC-EAWAG Switzerland Tchonda, Tetouehaki Financial viability of faecal sludge collection and transport operators in Ouagadougou, Burkina Faso
11h15	University of KwaZulu-Natal South Africa Lorentz, Simon Assessing pollution risk from buried sludge	Water and Sanitation Association of Zambia (WASAZA) Kellner, Christopher Pilot project on FSM in Lusaka, Zambia	Water and Sanitation Programme, World Bank, Mocambique Muximpua, Odete Building blocks for effective FSM in peri-urban areas: the role of Small-Scale Independent Providers (SSIP) in Maputo
11h40	Viv Mostert and Associates South Africa Mostert, Viv Dealing with the rural sanitation backlog in the Chris Hani District Municipality – a case study	University of Dakar / SANDEC Senegal Niang, Seydou From Waste to Resource - Research on FS Drying Beds in Dakar, Senegal (DAR - De Dechets à Resources)	North Carolina State University USA de los Reyes, Francis Hygenic pit emptying with low cost auger pump
12h05	Water for People Malawi Magoya, Joseph Direct mode solar sludge drier	Makerere University / SANDEC Uganda Semiyaga, Swaib Market demand for FS treatment end products in Kampala, Accra, and Dakar	Mott MacDonald UK Radford, Jamie Physical characterisation of pit latrine sludge
12h30	Makerere University / SANDEC Kampala Nakato, Teddy Fuel Potential of Faecal Sludge - Calorific Value Results from Uganda, Ghana, and Senegal	University Ahmedabad India Chawla, Chandan Choosing an appropriate sanitation system for citywide sanitation for small towns in India	Water and Sanitation for the Urban Poor, Mozambique Baghiratan, Vanniasingham Working small sanitation enterprise for FSM in peri-urban Maputo: the experience of WSUP
12h55	Lunch		

Plenary Session (P3) Chair: Chris Buckley

14h00	Panel Discussion So what's new? What might FSM look like in 2050? This topic will be introduced by the keynote speakers and then opened up to the floor
15h15	Jay Bhagwan, Research Manager, Water Research Commission Closing Address

Monday 29 October 2012 / Opening Session P1: Main Hall

Welcome

Dhesigen Naidoo
CEO, Water Research
Commission of South Africa

In his welcoming address entitled: *Faecal Sludge Management, A case for STI Investment,* Naidoo provided an insight into the role played by the Water Research Commission - South Africa's Premier Water Knowledge Hub. The WRC will contribute solutions to South African, African and Global water challenges through Research and Development by developing and harnessing the water research and development capability in South Africa.

FSM – is a complex matter that incorporates a number of aspects including: • Financial factors • Technological and infrastructure factors • Energy budget factors • Source potential • Cultural acceptability • Social acceptability • Political factors.

When considering the S&T solution, some of the key points to be considered include the fact that water research output in the Thomson Reuters ISI indices has been steadily increasing with time, and although the world share percentage has dropped from 3.5% in 1982 to 1.61% in 2010, it is still more than three times the SA overall average for all disciplines. At the same time the relative impact has been restored to 1982 levels. SA's water research has been growing slower than international peers. At 1.61% world share it has a higher performance than some premier SA priorities like astronomy (1.00%), biotechnology (0.82%), energy and fuels (0.60%). The WRC has more recently initiated a dialogue to consolidate several initiatives to build investment and human capital development in this domain.

Durban - Looking beyond conventional sanitation solutions

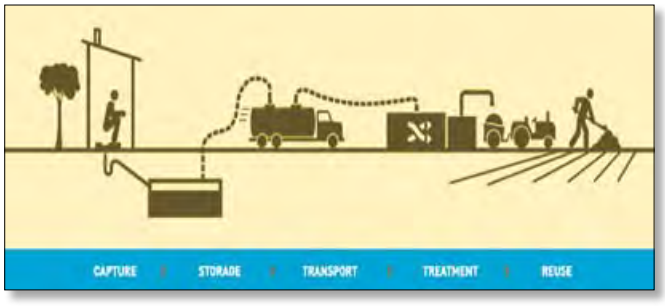
Neil Macleod
Head, Ethekwini Water and Sanitation (City of Durban)

Worldwide, research has shown that when it comes to sanitation, people want a flushing toilet as it is a solution that is clean, safe and odour free. In his presentation, Macleod provided an insight into eThekwini Municipality's 70 000 to 80 000, urine diversion toilets, that provide a unique a solution to a large number of the residents. The solution, separates the urine from the faeces, but necessitates that the municipality spends millions per annum, transporting the mixture to where it is processed. Overall, sanitation is about the human experience. If we can achieve equity and technology together, we will break-through the acceptance barrier. What is needed, is one solution for all, one service and technology that applies to everybody. If we can find a solution that is effective, and that deals with sustainability issues, we will take the world's sanitation challenges one step forward. In order to achieve sustainability, it will be necessary to find a way of converting this value chain into a business, so that there are incentives for people to get into the industry and to remain in the industry from a business viability perspective. It is only recently that people are starting to see and realise the value of faecal sludge as a resource. The right business model, for decentralised solutions will be required to make sanitation a reality. Ultimately, we will end up with a sustainable solution – where people will want to get into the business of emptying toilets, as they will make money out of it. It is a solution that will work at all levels, including from an environmental perspective. If one considers the mobile phone paradigm, some 20 years ago there were no phones. Today, in most African countries, everyone has at least one phone, if not more. We need a similar approach as a solution for the world's sanitation challenges, one that doesn't require the laying of kms of sewer lines. When we achieve this solution, the result will be better than what they have always thought is the best sanitation technology. At this conference, taking place here in Durban South Africa, we have the people with the expertise to find these solutions.

An overview of the FSM work of the Bill and Melinda Gates Foundation

Doulaye Kone
Senior Programme Officer,
Global Development, BMGF

At the roots of the lingering sanitation crisis 2.6 billion people globally do not have access to improved sanitation. The current approaches cannot reach the required scales, with figures such as 1.1 billion people that still defecate in the open and more than 1 million children under the age of 5 dying as a result each year. The BMGF works with a wide range of partners through its Water, Sanitation & Hygiene (WSH) program to reduce the burden of water-borne disease and improve the lives of the poor. Their approach aims to expand the use of sanitation that does not connect to a sewer. The foundation invests in effective approaches that help end open defecation and unsafe sanitation in rural communities, and helps to develop the tools and technologies that will allow the urban poor access to sustainable non-piped sanitation. Their initiatives include: 1) Sanitation Science & Technology 2) Delivery Models at Scale 3) Policy & Advocacy 4) Monitoring, Learning & Evaluation. The WSH program initiated the Reinvent the Toilet Challenge to leverage advances in science and technology and create a new toilet that will transform waste into energy, clean water, and nutrients. The Reinvent the Toilet Challenge aims to achieve the following goals: • Address the failures of the 18th-century toilet, which is not meeting the current needs of 2.6 billion people who lack access to sanitation • Devote funding and attention to the need for a new toilet • Generate innovation among a wider research and development community • Support upstream research and development of a toilet with the following specifications: Affordable: Has an operational cost of less than $0.05 per user, per day, moving towards $0.01/person/day as the end goal. Safe: removes all pathogens from the environment. Appealing: sustained use > 5 years. User-centered: users create demand. Sustainable: service providers (public or private) can recoup complete lifecycle costs.



Reflections on business models and technology designs for pit emptying services

Steve Sugden
Water for People/London
School of Tropical Health
and Hygiene

The development of new, low cost pit emptying devices such as the Gulper seems to have catalysed interest in creating much needed new pit emptying services for the unplanned slum areas in cities of the developing world. Whilst improving the technology is a good first step, it is not the total solution and much work and innovation is still needed to achieve sustainable pit emptying service. Simple engineering based decisions such as the type of power source to use or the components to use can have a major impact on viability of emptying businesses that have to manage the day to day operation of the device. This in turn affects the sustainability and scalability of any emerging pit emptying industry. There is no such thing as the perfect pit emptying device. Different operators and different business models require different solutions and there is room for very simple low cost human powered devices at one end of the spectrum and complicated fossil fuel powered devices at the other. It is the role of the product designer and the market development organisations to understand their customers and to design better, cheaper urban sanitation technologies and to meet their anticipated needs and desires. The existing latrine providers in urban areas are usually a cohort of poorly trained and not very entrepreneurial informal masons. They offer latrine construction services to households using designs often aimed at maximising their income as opposed to providing a cost effective efficient solution to the householder. If latrine building is going to happen at the scale required, a new breed of sanitation entrepreneurs needs to enter the market and it is important that they are not held hostage by the traditional attitudes and practices of masons. This points toward deskilling the latrine building process and to change latrine building in the developing from a service with products attached, to a product with services attached. This is the 'Ikea' approach to latrine building and is already showing signs of considerable success with organisations such as WaterShed in Cambodia.

Challenge critical: Absence of faecal sludge management shatters the gains of improved sanitation coverage in Bangladesh

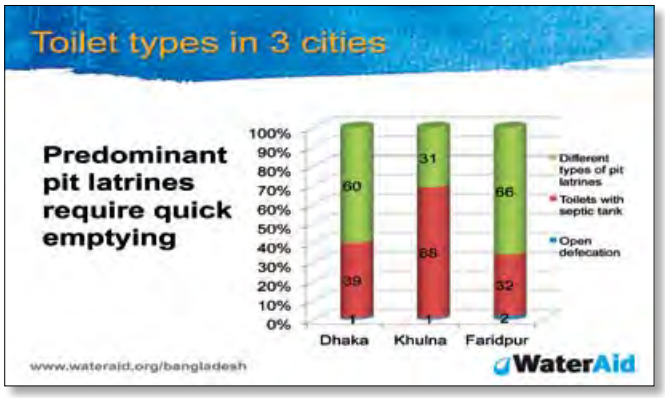
Aftab Opel

WaterAid has conducted research on Faecal Sludge Management (FSM) that has been funded by the Bill & Melinda Gates foundation. The research undertaken comprised a 'situation analysis' of 3 cities (Dhaka, Khulna and Faridpur).This study forms part of a multi-country study in Asia and Africa. Improved sanitation coverage in Bangladesh is slowly increasing, although overall the country is far behind in achieving universal sanitation coverage. However, the increase in onsite sanitation has created a new challenge of faecal sludge management, one that is still not adequately considered at policy level. The study demonstrates that in the absence of safe emptying, transportation, dumping and treatment mechanisms, most of the sludge generated is returned to the surface water, ultimately shattering the gains achieved through increased sanitation coverage. With predominantly on-site technologies, most septic tanks and/or pits in the cities require emptying which is mostly done by the manual sweepers. With the exception of Dhaka, no cities have any designated dumping site or treatment plant for faecal sludge. Consequently, manual sweepers dump the sludge in nearby open drains or water-bodies.

The study has identified various potentials of sludge as follows:

- Bangladesh uses around 3.5 million tons of fertilizer each year of which about 2.6 million tons are imported.
- Government provides subsidy @ Taka 18/kg to the farmers.
- If the entire amount of sludge produced in the country could be converted into proper fertilizer that will turn up to 3 million tons.

The paper presents an analysis of systematic data collected from three cities in Bangladesh on current management practices, and highlights the importance of improved sludge management.



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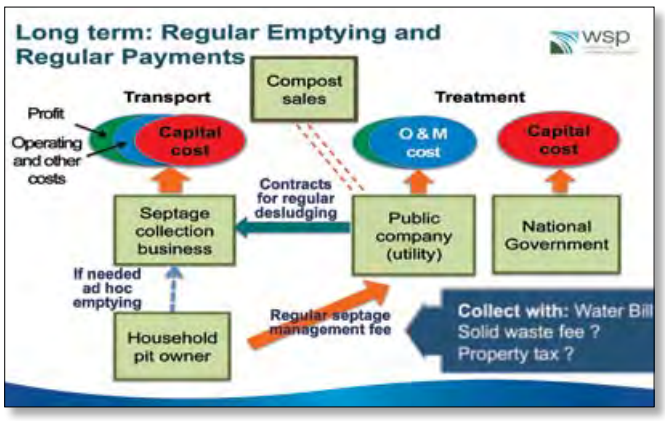
Indonesia: Development of urban septage management models

Sandra Giltner*, Martinus Warsono**, Budi Darmawan***, Isabel Blackett**** and Kevin Tayler****

This paper outlined the findings from field work and proposed management models in two Indonesian cities: Tegal (population 250 000) in Central Java, and Jombang (population 200 000) in East Java. Almost half of Indonesia's 238 million people live in urban areas. As part of the Government of Indonesia's Acceleration of Sanitation Development in Human Settlements Program, the use of on-site sanitation systems in urban areas will continue. In dense areas, small decentralised wastewater treatment systems will be developed resulting in an increasing demand for septage emptying services. The Ministry of Public Works has evaluated the technical design and performance of many existing septage facilities in preparation for investment in rehabilitation and new construction, including evaluation of 28 septage treatment plants in Java in 2010. Many of the evaluations concluded that there was sub-optimal ownership of the septage treatment facilities by local governments; the institutional arrangements for operating the facilities and the operation and maintenance budgets were poor, and the staffing and staff capacity was low. The Ministry of Public Works has requested technical assistance to support national investments in septage infrastructure and local governments to improve urban septage management. The assistance will develop sustainable management models for operating and maintaining septage systems. The key areas of this presentation addressed the following aspects:

- Current septage system practices and shortcomings.
- Incentives and disincentives to local government for improved operation.
- Proposed management model with potential for increasing the sanitation value chain by reuse of septage.
- Short and medium term actions for local governments.
- Application of lessons learned for other cities in East Asia and elsewhere.



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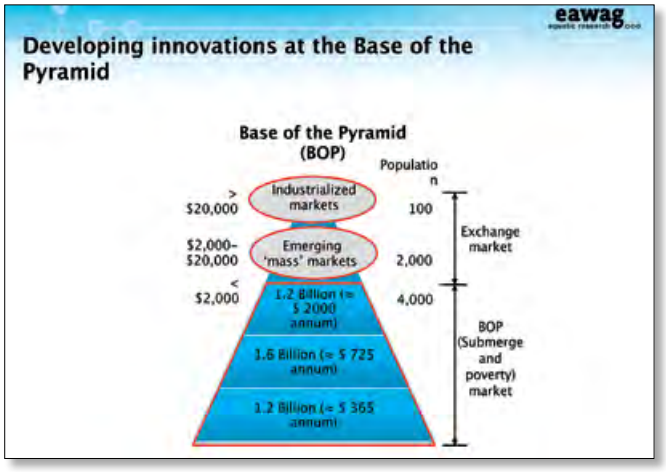
Business Model Innovations for Scaling-up FSM Businesses in low- and middle-income Countries

Lars Schöbitz*(1), Heiko Gebauer(5), David Robbins(2), Miriam Otoo(3), Pay Drechsel(3), Vishwanath Srikantaiah(4), and Linda Strande(1)

The paper provided an insight into the business challenges in the scaling-up process of FSM. It provided guidance for increasing geographical coverage, enhancing usage of emptying services, and increasing affordability of sanitation services at the household level. The majority of urban populations in low and middle-income countries rely on on-site sanitation systems, which produce large amounts of faecal sludge. Collecting and treating faecal sludge could provide a viable business opportunity for private firms or public organisations. Despite the increasing efforts to create sustainable and economically viable businesses in the context of FSM, most businesses are still in the mode of securing their existence and maintaining their survival. Scaling-up entails reaching a critical mass and being able to cover a certain geographical service area. Scaling-up implies that the business provides reliable emptying services which are affordable for poor people. An example of scaling-up is that businesses not only provide emptying services, but also faecal sludge treatment and resource recovery. IWMI and Sandec/Eawag are exploring the role of business model innovations in the scaling-up process of FSM. The preliminary results suggest two distinct paths for how business model innovations can drive the scaling-up processes: (i) organic business growth; and (ii) replication of micro-enterprises. An 'organic' business growth means that the FSM enterprise attempts to make a stepwise extension of the business. Critical innovations in the business model refer to the tariff system, business planning and execution, and the market development for value added end-products. Micro-enterprises are small firms that specialise in FSM. They are operated with few employees (e.g. entrepreneur, helper, driver). Micro-enterprises compete with each other, and this in turn leads to affordable prices.



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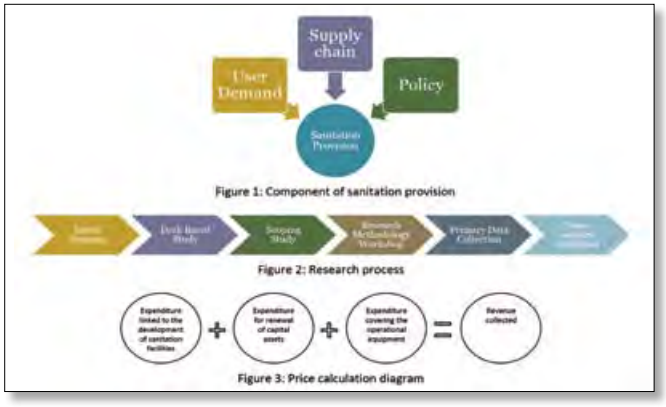
The impact of prices and tariffs on faecal sludge management in Africa

Ujah Oliver Chinedu*, JeanMarc Yofe**, Lucia Henry**, Joseph Wethe**, Gilles Djagoun**, Idrissa Doucoure** and Mansoor Ali***

The MDGs identified sanitation services as key factor in lifting people out of poverty. Sanitation is a complex and multi-faceted sector with a wide range of service providers, technologies and approaches interwoven with distinct cultural, institutional and sectoral environments. These variants can be viewed as being comprised of three main components; supply chain, user demand and policy environment. The social and economic benefits of providing quality sanitation to the poor are colossal, but such benefits are realised at very high costs to investments or utilities. Tariffs and prices/charges are the means by which private and public utilities achieve fiscal sustainability. Just like in most sectors, cost recovery is crucial for investments in the sanitation sector. African utilities (both private and public) operate in a high-cost environment. These high costs, occasioned by the need to recover investments and cover at least partial operation and maintenance costs, make sanitation prices and tariffs higher in the continent. This paper investigated this issue based on a recent urban sanitation price and tariff benchmarking case study carried out in six countries of Africa by WSA and other partners. The research process involved five major stages, including development of data collection tools, preliminary exchange meetings, field data collection and analysis, national validation workshops, and report writing. The impact of prices and tariffs were examined using five major criteria: equity, economic efficiency, fairness, affordability, cost recovery and incentives for scale up.



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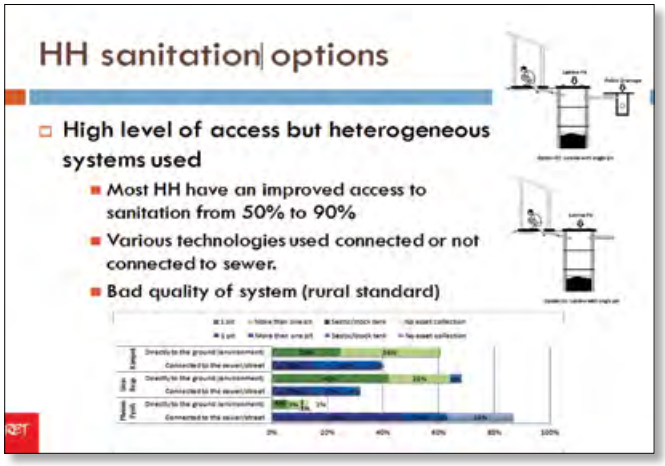
Domestic private faecal sludge emptying services in Cambodia: between market efficiency and need for sustainable management

Clément Frenoux* and Alicia Tsitsikalis**

Based on a large field study on supply and demand of FSM emptying services conducted in three Cambodian cities in 2011 (Kampot, a small city, Siem Reap, a medium-sized city and Phnom Penh, the capital), this study aimed to assess the viability and efficiency of current urban FSM emptying services. Over the last two decades, Cambodia has experienced rapid economic and urban growth but still faces numerous challenges, one of them being urban sanitation. While access to improved sanitation reached 29% of the total population in 2008, there remains a gap between rural areas, where access is low, and urban areas, where access is high (80%). The current Cambodian urban sanitation situation produces strong negative environmental externalities that do not create a sustainable urban sanitation management system. Field study results confirmed that access to sanitation in urban areas of Cambodia is high but strongly heterogeneous (with a particular mix of on-site and off-site sanitation). Studies also show the domestic private sector is already delivering most sanitation services characterised by affordable construction and maintenance tariffs (50 US$ to build latrine). At the downstream of the value chain, results show that the market of FSM emptying services is also dominated by small domestic private operators, characterised by high competition and a market based approach. Most of them are profitable and efficient, providing good quality FSM emptying services at a cheap tariff (20 USD to 50 USD), thanks to an adapted business model based on low market entry costs. This paper highlights the difficulties of regulating this service, the importance of adapted institutional arrangements and following cities characteristics (size of market, treatment and transport technologies).



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Best practices in faecal sludge management – Lessons learned from 4 case studies in the Philippines

David M Robbins* and Julian Doczi**

In July, 2012, site investigations and interviews were performed to evaluate four FSM programs in the Philippines. The purpose was to report on lessons learned and best practices for cities wishing to implement their own projects under the new NSSMP, which had become law in June, 2012. The NSSMP is mandated by the Clean Water Act and provides up to a 40% cost share for sewerage programs. It provides technical assistance, capacity building and promotions for septage management. The program targets highly urbanised cities and municipalities. This presentation highlighted the overall findings of the programme as follows:
1. A national program is key to successful coordination, promotion and implementation of wide scale faecal sludge management programs; 2. Estimating the volume of sludge produced is difficult, but can be successfully accomplished through site visits and surveys organised through rapid technical assessments; 3. Determining the frequency of septic tank or pit emptying needs to be evidence based and not arbitrary, either by considering volume and usage statistics, or by physical inspection; 4. Maximising customer participation through an enabling environment that includes adherence to a bottom-up planning process, on-going promotions campaigns, and incentives is critical for meaningful impact of FSM programs; 5. A sustainable, fair and scalable tariff schedule needs to be implemented to ensure that the business plan is financially viable; and 6. Implementers need to be realistic about cost recovery when planning biosolids management schemes.

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The informal sector in Faecal Sludge Management – A perspective from India

Srikantaiah Vishwanath* and Shubha Ramachandran, Avinash Krishnamurthy**

This paper provided an insight into the development of a faecal sludge management framework that is in the process of being developed in India. It discusses options as to how the state to could regulate the services effectively and recover the highest value with public health safety and hygiene in mind. In India, there has been an increase in the number of honeysuckers – vacuum sludge cleaning trucks - driven by the strict implementation of the Manual Scavenging Act which prohibits the use of humans for cleaning pit toilets and septic tanks. Mechanisation is seen as the only way to eliminate manual scavenging of pit toilets. The recent Census of India 2011 has revealed that there are 54.76 million households connected to septic tanks and 73.65 million households connected to pit toilets in India. Another 113 million rural households and 14 million urban households are likely to connect themselves to mostly pit toilets and septic tanks in the future. This represents a significant faecal sludge management challenge. The informal sector has played a major role in the supply of these vehicles and the service provided by them. They run a financially sustainable business with a nutrient resource recovery potential. However the nutrient recovery is also happening mostly in the informal sector with farmers converting sludge into compost and using it as a fertilizer. Farmers also realise a profit in the reuse of sludge. The entire value chain so created runs as a business model with service being provided and values being realised by every actor.

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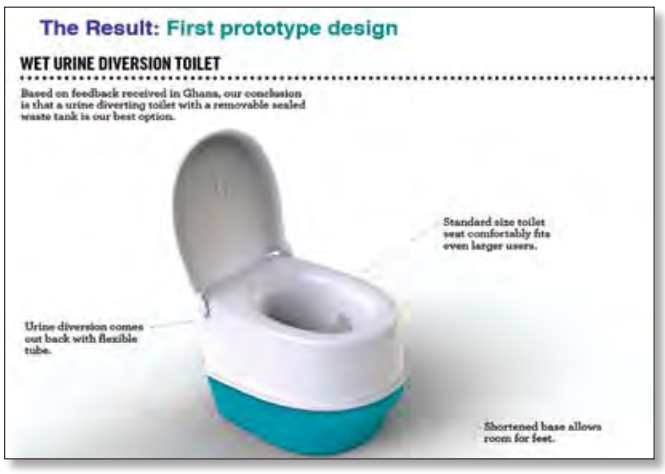
Monday 29 October 2012 / Session A3: Main Hall

Clean Team: An affordable sanitation service with soul

Andy Narracott

Clean Team is an end-to-end sanitation solution. The company's mission is "to do sanitation right for the consumer, introducing comfort and convenience into in-home sanitation". It is Clean Team's objective to see the demise of long walks and long lines, and put an end to unpleasant experiences inside uncomfortable facilities. Clean Team is a smart in-home toilet service that is not only a sanitation business, but also a social business. It is the result of a collaborative partnership between WSUP and Unilever that began exploring opportunities for urban sanitation in September 2010, and started a 6 month pilot in July 2011 serving 100 households in Kumasi, Ghana. It has fused sanitation and branding expertise to create a desirable market-based sanitation service that people want and can afford. Customers are provided with the engaged, reliable, and polished service we call Clean Team: a sanitation solution set on redefining the status quo. When the waste leaves the household, it is disposed of responsibly; when employees are recruited, they are trained in customer service as well as hygiene and personal safety; when business is conducted, it is done for public health as well as profit; and where opportunities exist, economic value is created from human waste. The Clean Team toilet is supplied to customers free of charge in return for a regular service charge. The toilet is emptied 2-3 times per week by trained operators, and a Service Associate visits the household regularly to collect service charges and sell hygiene and cleaning products. The waste is taken to a site in the local area for emptying and onward transport to municipal treatment sites by vacuum trucks. Following a successful pilot, the business will soon be serving over 1000 toilets in three low-income neighbourhoods of Kumasi.



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Financially and Culturally Sustainable Applications of Loowatt Technology in Antananarivo, Madagascar – Early Feedback

Iain Purves* and Virginia Gardiner**

Loowatt Ltd. has developed and tested a waterless toilet that packages human waste into biodegradable polymer film. A patented sealing mechanism separates liquids and solids, provides an odour-free user experience, and creates a barrier to disease vectors. The waste and the film are converted into two valuable commodities, energy (biogas) and fertiliser, through anaerobic digestion. The focus of this research is to understand how sustainable micro-economies can be built around the toilet system and its by-products, and how these systems can benefit the users and local community. A pilot project is currently underway in Antananarivo, Madagascar. Loowatt are installing toilets along with an anaerobic digester to produce biogas, and a facility to create organic compost from digestate. The objectives are to:

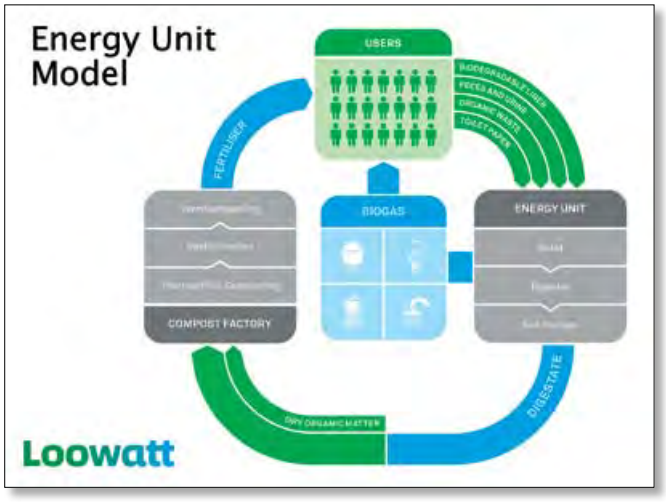
• Understand local culture, preferences, and need surrounding sanitation, and to deliver a solution that ensures community acceptance and continued use. • Gather feedback on the Loowatt toilet system and commodity products. • Validate Loowatt's financial model of the Loowatt system in this context. • Measure the value potential of the commodities produced by the system.

• Position the system for scaling in Antananarivo following the pilot implementation.

Key findings: Commodity product values:

- Toilet use (poo): US 4.4 cents
- Toilet use (pee): US 2.2 cents
- Mobile charges: US 9.1 cents
- Hot water (10 litres): US 5.5 cents
- Fertiliser: US 83 cents /kg

An overview of these early results were presented at the conference.



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Multi-use collection bag for faeces and reusable menstrual napkin

Josef S Schneider

This presentation provided an insight into a multi-use bag that has been designed for the collection of faeces which can be fastened easily beneath the seat of a pit latrine. While this innovation does not provide a permanent sanitation solution, it offers an inexpensive improvement in sanitation to potentially millions of people in the developing world, until sustainable technological solutions are developed by preventing the problems associated with full pits and pit emptying, and facilitating easier handling of sludge. The design also allows for the separation of faeces from urine for different applications. The collection bag is made from a lightweight, high-strength nonwoven textile which is readily available in many countries. Solid waste is collected and contained in the bag while liquids pass through freely. The capacity of the bag allows for up to 5 uses before it needs to be replaced. Once the bag has filled with solids, it is hung in the sun for drying, where bacteria will eventually degrade it into a composted material which can be used as a fertilizer or burned as an alternative fuel source. The urine which has drained through the bag can be collected separately for other uses. The material cost per bag is less than 3 cents (USD) and this cost is off-set by the saving of pit emptying costs. Bags can be produced locally, potentially providing employment opportunities. In addition, a light-activated technology has been developed for the production of a reusable/ washable feminine napkin. Tests using this technology on a photodynamic dye polymer treated fabric have demonstrated that it effectively causes die-off of Candida spp and other pathogens which can cause reproductive tract infections. Sample napkins are presently being evaluated by cooperating organisations in Kenya.

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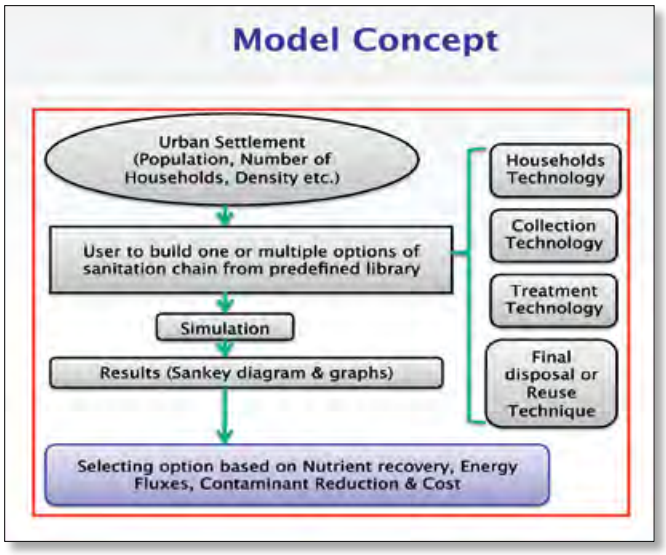
Monday 29 October 2012 / Session B1: Breakaway 1

Simulating nutrient and energy fluxes in non-networked sanitation systems

LC Campos*, V Jain*, M Schuetze**

This presentation highlighted a simulation tool for modelling the fluxes of human excreta from household to final disposal/reuse, focussing on fluxes of nutrient, energy and water. The simulator enables a comparison of conventional sanitation systems (i.e. flush toilet and pit latrines) with "new technology systems" such as urine diversion and vacuum toilet systems. The simulator aids in determining sustainable sanitation solutions for the boundary conditions of the respective site based on material flow analysis. The amount of nutrients and energy available for recovery provide an indication of the economic potential of waste reuse. Simulation models provide a cost-efficient means to simulate these technologies under several scenarios and to identify the most sustainable sanitation solution for a given case study site. These provide city managers with a tool to aid decision-making from a macro-perspective to assess the application of these technologies within their city. However, existing simulation models for sanitation planning in developed countries focus mainly on networked systems and are thus not appropriate for the situation in many African and Asian cities. This paper illustrates its adaptation and application to the context of non-networked sanitation systems, using a city in Africa as an example. The model outputs include the main fluxes of nutrients, water and energy and, thus, their available amount for recovery, volume and quality of treated waste for reuse, and an estimate of pathogen reduction. Moreover, the model gives a potential monetary value for reuse of residuals. Once further developed, the model could aid city-managers to evaluate and compare alternative sanitation technologies and, thereby, to select the most sustainable and cost-effective solution.



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The sustainable sanitation design concept for sludge treatment for cities in Africa

Karsten Gjefle

This presentation highlighted the SuSan Design Secondary Treatment Unit (2nd TU), where sludge is handled with a methodology developed in cooperation with the Swedish University of Agricultural Sciences. The treatment methodology is science based, thoroughly tested and certified by SLU researchers. It has proved to be a robust and cost effective method for up-cycling human excreta to a safe natural fertiliser and soil conditioner. Through local entrepreneurs the potential exists to change the view on human excreta from community cost driver to value creator. The treatment process is low-tech, cheap, and suitable for decentralisation. The intention is to create a network of entrepreneur-managed treatment units, organised within the framework of national franchises or local cooperatives. The treatment methodology, if scaled up across Africa, can potentially bring enormous volumes of safe fertilizer and soil improvement products to agriculture, resulting in flower export and fodder production to sustain the growing urban populations who depend on locally produced food. In addition to the fertilizer aspects, our units will replace pollution with green economic growth. The main advantages of our treatment system are:

• It can become an integral part of the mix of existing sanitation systems. • It creates incentives for low water use and safe nutrient recovery. • There are no bottlenecks in scaling up to units serving millions of users with decentralised treatment units in cities across Africa. • No external energy is needed to run the process. • The nutrients in the sludge are well suited for conservation/low till/sustainable agriculture.

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Vacuum source-separation eco-san and the decentralised wastewater management in China: practical application and the prospect

Bin Fan*, Yuqi Liu**, Wenyuan Yang***

Supported by GCE of the Gates Foundation, a vacuum source-separation system was designed. The system integrates collection of domestic faecal sludge and kitchen wastes, and treatment and fertilizer utilisation of animal manures and agricultural wastes. Aspects of the technical system were demonstrated by a pilot engineering project located in Chentang Village, Guli Town, Changsu City (county) in China. The pilot system has been running for more than 18 months, obtaining wide support from villagers and local officials. Even though the main equipment was not batch produced, the total engineering cost was $1 630 per toilet, close to that of projects using the traditional wastewater treatment executed by the local government. The measured average flushing water per time use was 0.52 L, and the total electric power consumption was 2-3kWh per day for 23 families. Though as an expedient measure, now the collected faecal sludge is stored for 3 months and used as fertilizer by the villagers, but it is expected this will be absorbed by a local fertilizer-agriculture union if a certain amount of engineering is done.

China is a country developing at high speed. After three decades of rapid economic growth, the focus of national social and economic development is gradually moving to environmental and social welfare. Nearly 2/3 of the population of 1.3 billion do not have modern sanitation and public sewage service. It is estimated that local governments will need to build decentralised sanitation establishments for more than 500-million people in the next 20 years. In the draft master plan submitted to the Ministry of Housing and Urban-rural Development of the People's Republic of China (MGURD), the concept of eco-san – water and energy saving, low running cost, and recycling economy – was given special importance among the three recommended technology patterns. Based on comprehensive comparison and argumentation, it is considered that the vacuum source-separation eco-san is appropriate and available to service hundreds and millions of people living in developing villages and small towns, and those urban residents unreachable to city sewage works. The local government has consented to scale up this technology in the whole county, and several new engineering projects will be put into execution.

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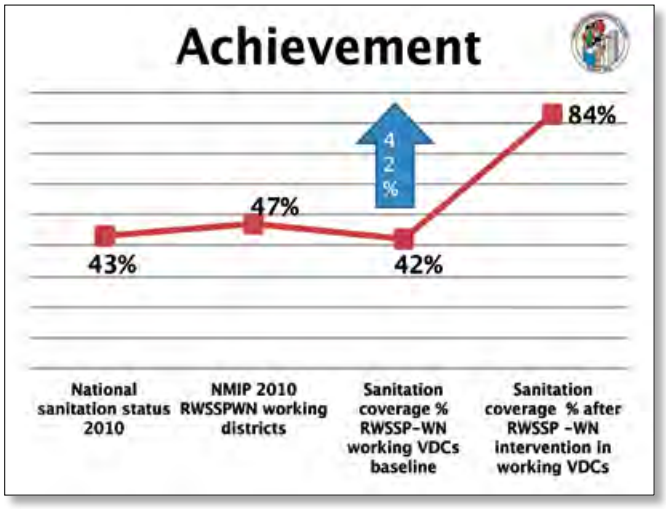
Investing in People – Using human shit and urine as organic fertilizer, energy saving and economic development in Vulnerable Communities of Nepal

Chhabi Lal Goudel

The RWSSP-WN has been implemented since 2008 in 54 VDC´s (Village Development Committees) of nine districts in western Nepal. The RWSSP-WN was designed to improve wellbeing of the poorest and excluded households. The purpose of the project is to fulfil the basic needs and ensure rights of access to safe domestic water, good health, sanitation and hygiene through a decentralised governance system. The project piloted an approach called "Community Led Total Behaviour Change in Hygiene and Sanitation"(CLTBCHS) in these VDC´s. In this approach, local bodies are facilitated and local people are trained to ignite awareness and trigger people to build ECOSAN toilets, and to use human shit (after composting) and urine as an organic fertiliser. A total of 553 community level structures and systems were mobilised for the purpose. In total, 6 700 community level sanitation triggers (49% female) were trained from a population of 430 000 in 5 6000 households in the project VDC´s. Included in the project are economic development and energy saving by using human shit to produce bio-gas. Activities focussed on integrated community led ecological sanitation and sustainable livelihoods have been implemented, helping to mitigate the diverse pressures on the unique Agriculture Ecosystem, and helping to ensure that the needs of local community members are adequately addressed. Research shows that the use of human shit and urine demonstrates agricultural production four times that of chemical fertilizer (imported urea in Nepal). Each VDC of Nepal spends approximately USD 5800 (i.e. on average 10 kg/HH x USD 0.58 = USD 5.8 x 1000 HHs = USD 5 800) to buy chemical fertilizer per year. For 3 915 VDCs the annual cost will be USD 227 600 00. As a result, it is assumed that faecal sludge management, food security and energy saving within the project working area has greatly improved, resulting in a reduction in morbidity and mortality from hygiene and sanitation related diseases.



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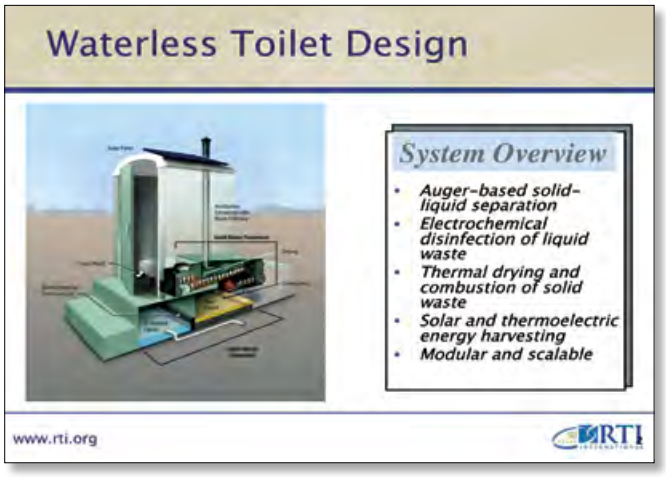
Monday 29 October 2012 / Session B2: Breakaway 1

A waterless toilet with electrochemical disinfection and biomass combustion

BR Stoner*, D Stokes*, M Elledge*, D Robbins*, M Mazibuko**, CB Parker** and JT Glass**

RTI International in partnership with Duke University and Colorado State University, in response to the RTTC 2 by the Bill & Melinda Gates Foundation, are developing a fully integrated toilet system that combines electrochemical disinfection technology for liquid waste processing and recovery, with a revolutionary new biomass energy conversion unit to both process the solid waste and convert it into recoverable energy.The presentation focused on the overall system design, including detail on the functional elements along with preliminary energy balance and economic analysis. The system is designed to be energy neutral, requiring no external sources of power or sewage utilities. The proposed toilet design will consist of three primary elements: 1) the conversion of solid waste into a burnable fuel; 2) the use of thermoelectric to convert thermal combustion energy into stored electrical charge; and 3) the electrochemical disinfection of liquid waste. The toilet is designed to take advantage of current best practices in sewage and waste management while also leveraging recent innovations in energy harvesting and waste treatment. Disinfection will be the primary objective for the liquid treatment so that the by-product may be used for non-potable applications, such as toilet rinse and agricultural fertilization. The waste handling and transport design consists of a manual/mechanical auger-based system that separates liquid from solid and then converts the solid waste into a combustible fuel. With heat from the combustion process, the uniform faeces pellets are dried and converted to a burnable fuel. Thermoelectric modules will convert thermal to electrical energy to charge a battery which will drive the electrochemical disinfection processes. The liquid treatment will rely primarily on electrochemical oxidation using diamond-based electrodes for enhanced performance and energy efficiency.



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Sanitisation of faecal sludge by ammonia

Fidjeland, Jörgen*,** and Vinnerås, Björn*,**

Just having toilets is not enough to avoid transmission of faecal pathogens. Disposal of faecal sludge into waterways is causing major outbreaks of diseases, especially in areas with high population density. Faecal sludge is rich in organic matter, nitrogen and phosphorous, and could be used on agricultural fields to increase crop yields. In order to do this in a safe way and avoid transmission of diseases during farming and food consumption, the pathogens in the sludge need to be inactivated. One possible treatment option for faecal sludge is ammonia sanitisation. Ammonia sanitisation is a simple, low cost method which utilises the pathogen inactivating effect of uncharged ammonia (NH3). The treatment is easy to manage as it only requires an airtight storage facility to avoid ammonia losses by evaporation, and sufficient ammonia concentration and treatment time for pathogen inactivation. For treatment of faecal sludge, the ammonia from the urine may be enough for sanitisation of the material, depending on flush water volumes and ambient temperature. Inactivation studies at lab scale have shown that approximately 50 mM uncharged ammonia is necessary for efficient inactivation of Ascaris eggs, which is one of the most persistent faecal pathogens. Preliminary results indicate that this concentration is possible to reach using less than 5 L flush water per person and day, although this depends on urine concentration and the ambient temperature. Lab scale studies of faecal sludge showed that a 6 log 10 reduction of Ascaris egg viability can be reached by 3 months of treatment at 22°C with a NH3 concentration of 70 mM, and higher temperatures and ammonia concentrations increased die-off considerably. Current WHO guidelines recommend >1 year storage of faecal sludge before agricultural use, and some studies indicate only a small reduction of viable helminth eggs during that period. By quantifying and utilising the pathogen inactivating effect of ammonia there is a potential for faster and more efficient faecal sludge treatment.

Urea nitrogen fertilizer
Source: www.chimicare.org/

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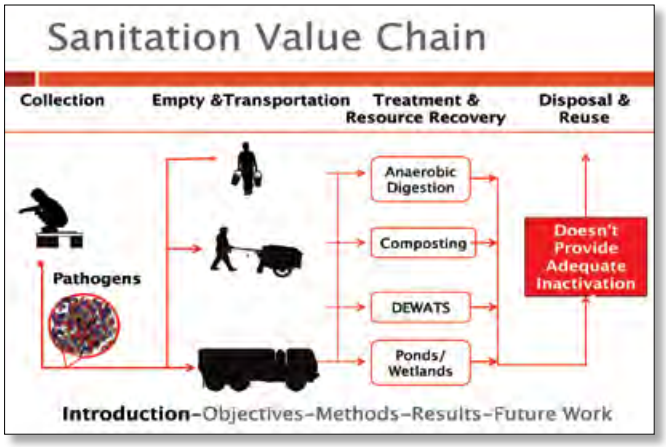
The Disinfection of Latrine Faecal Sludge with Ammonia Naturally Present in Excreta

Temitope A Ogunyoku and Kara L Nelson

Current faecal sludge management practices are ineffective and often expose populations and the environment to excreta that contain high concentrations of pathogenic organisms. The purpose of this research is to develop a low cost method that completely disinfects sludge in pit latrines/excreta collection containers prior to waste emptying, transportation, and sludge treatment. This is achieved by treating excreta at the point of collection by harnessing ammonia from human waste. The disinfection approach of this research is to convert urea and ammonium (NH_4^+) naturally found in urine and faeces into a powerful disinfect (i.e. NH_3) by adding an alkalinising agent to raise the pH level. It is planned to report results from the following laboratory experiments:

- The conversion rates of urea to ammonia with urease naturally present in faeces and synthesized urease.
- The inactivation of MS2 coliphage under the following conditions: different ratios of urine to faeces, alkaline agents (calcium hydroxide, biochar, ash, limestone pellets), pH levels (range 7 - 11), time (0.5 - 720 hr), and temperature conditions (32 - 52 °C).



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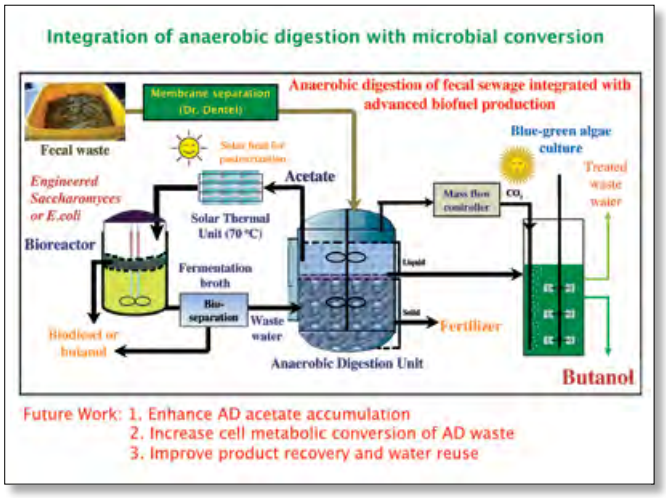
Monday 29 October 2012 / Session B3: Breakaway 1

Metabolic engineering of microbial platforms to convert anaerobic digestion wastes to biofuel

Yinjie J Tang[1], Yan Liu[2], Yi Xiao[1], Arul M Varman[1]

Anaerobic digestion uses a microbial community to break down biodegradable materials (such as agricultural or human wastes) and to release bioenergy. The AD process also has applications for reducing pathogens in the bio-wastes. The process produces methane and nutrient-rich digestate, useful for bioenergy and fertilizer respectively. However, AD by-products (CO_2 and acetate) have not been well utilised. In this study, two microbial platforms were engineered to convert CO_2 and acetate to advanced biofuels. Firstly, *Synechocystis* sp. PCC 6803, a cyanobacterium that can utilise CO_2 for the synthesis of isobutanol, was engineered. The Ehrlich pathway was introduced into the cyanobacterial genome. With expression of two heterologous genes (2-ketoisovalerate decarboxylase and aldehyde reductase), without using the inducer IPTG, the engineered strain can produce over 100 mg/l isobutanol photoautotrophically. Secondly, acetic acid can be generated by acetogenic bacteria during anaerobic digestions. Under unfavourable conditions (e.g., low pH), methanogens are inhibited and significant acetate is accumulated. To utilise such acetate by-product, an E.coli BL21 strain is engineered by overexpressing two native acetate utilisation pathways (i.e., ACS: Acetyl-CoA synthetase; PTA-ACKA: acetate kinase A and phosphotransacetylase). It was found that the sole over-expression of the ACS pathway significantly increases cell growth in the presence of acetate, but the over-expression of the PTA-ACKA pathway impedes acetate-based cell growth. Currently, construction of other biofuel producers (fungal species), which can efficiently degrade the solid anabolic digestion waste into biofuel, is underway. This study is to create diverse microbial hosts that can be used for converting all anaerobic digestion products into biofuel. The final goal is to develop an integrated anaerobic digestion process to co-digest energy/nutrient-rich faecal materials with other carbon-rich agriculture wastes (such as grass and corn stover), which eventually fulfill the multiple applications for pathogen inactivation, bioenergy generation, and fertilizer production.



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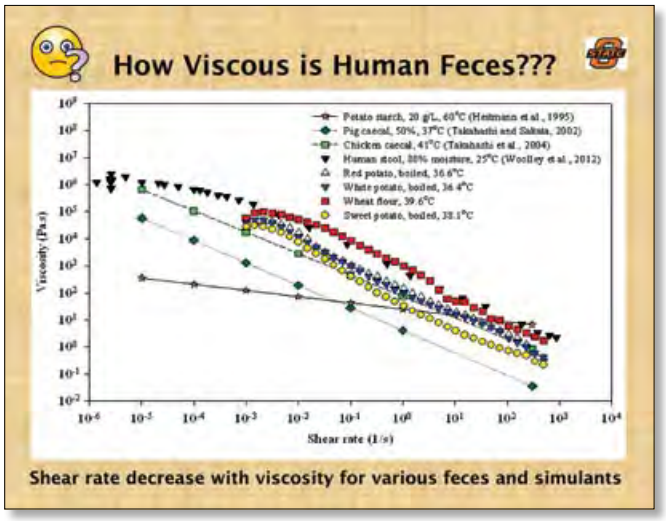
Treatment of faeces by viscous heating

Gary L Foutch*, Wali Islam**, Jagdeep T Podichetty **, AH Johannes**, Mason Reichard**

This study demonstrated that viscous heating of faeces through an extruder can achieve up to 200°C within 3-4 minutes. Additional time to process the mass generated by an individual requires only a few additional seconds. A laboratory-scale unit 10 centimetres long with a rotating central core and a space with the shell wall adjustable from 0.75 to 1.25 mm was operated with 5000-Pascal-second viscosity stimulants and parasite infected baboon faeces. At system geometries with larger spacing the observed temperature is lower, but shear stress and pressure remain as microbial destruction mechanisms. This size unit is sufficient to treat the mass produced by more than 1 000 people when operated continuously. When sealed the reactor generated a moist, hot mass. While moist heat is effective in destroying microorganisms, water must escape to dry the solid. Alternative designs are being evaluated to allow water to separate within the extruder. Another challenge is that spacing between the shell and the core is small and objects, gravel or sand in faeces will require screening prior to extrusion. The technology is also compatible with high-volume sludge processing and pit extraction applications. Experiments with baboon faeces are underway to quantify parasite destruction associated with heat, sheer and pressure shocks generated by the extruder.



Shear rate decrease with viscosity for various feces and simulants

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The proposal of plasma gasification for an off the grid sanitation solution

L Talsma* and JFM Molenbroek, M Crul, PV Aravind, G Stefanidis, A Navarrete Munoz**

The application of this technology is researched in two cases in India and South Africa, in urban slums with little access to proper sanitation. The cases were chosen because of the inhabitants' religion, government influence, use of toilets, climate, and type of settlement. To develop this technology for successful implementation, target group research is done in an early stage. Household spending patterns are documented, in combination with the perceived demand for sanitation. A complete service-system and user interface is developed to cater for the needs of the different use groups in the bottom of the pyramid. Plasmas are formed by passing an electrical discharge through a gas (e.g. air, helium).Controlled and very high-intensity microwave fields are used to generate plasmas in tailor-designed equipment of high efficiency in order to transform human waste into synthetic gas, which can be turned into electricity in solid oxide fuel cells (SOFC). Before gasifying the faecal matter, it has to be pre-treated. Fresh faeces contain around 80% liquid, which has to be limited for efficient gasification. Besides this, the waste has to be ground finely to ensure sufficient contact surface. Samples of sewerage sludge from the Netherlands are examined on composition and then gasified. The sample contains 1700kJ per 100g, promising for a system, which not only processes waste but also produces energy. The lab results show hydrogen after the gasification of the sewerage sludge, a first step in optimising the system and aligning the whole process from user to electricity. Presently, a continuous system is used – the gasification produces syngas, which can be efficiently transformed to electrical energy in a solid oxide fuel cell. For this, a feed of around 120kg is needed per day (with a plasma flame of 1kW and a reactor size of 1,5l), the human waste of around 1200 people.

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An overview of FSM research in Durban

Chris Buckley

This presentation provided an overview of research undertaken on FSM in Durban, South Africa. The Pollution Research Group (PRG) first became involved in dry on-site sanitation in 2004 through an investigation of the drying rate of faeces and cover material in urine diversion toilets in conjunction with the eThekwini Water and Sanitation. In 2005, the PRG received a project from the WRC to investigate urine diversion toilets in eThekwini and a second project to develop a scientific understanding of the design and operation of ventilated pit latrines. In 2007, the PRG was sub-contracted by Partners in Development to provide scientific support to a WRC project entitled *What happens when the pits are full?* In 2011, further research (commissioned by the WRC) was undertaken in conjunction with Partners in Development to investigate the deep row entrenchment of VIP sludges. In 2006 the PRG and eThekwini Water and Sanitation formally established a long-term agreement to work together in the field of water and sanitation services. This relationship provided access to data and facilities designed, constructed, owned or serviced by the municipality. Of equal importance was that there was almost continuous direct and personal contact between researchers, operators, designers and planners. In July 2009, a visit was made to the Bill & Melinda Gates Foundation (BMGF) in Seattle (together with Doulaye Koné and Blanca Jimenez) in order to provide first-hand experience of on-site sanitation to support the presentation of the proposed sanitation strategy to the senior members of the Foundation. In late 2009, Bill Gates travelled to Durban to see first-hand VIP toilets and urine diversion toilets and the associated difficulties associated with the management of the sludges from each system. In 2011, the PRG and local partners were one of the successful BMGF Reinvent the Toilet Challenge grantees. In 2012 the PRG received a grant from BMGF to determine the mechanical properties of faecal sludges.

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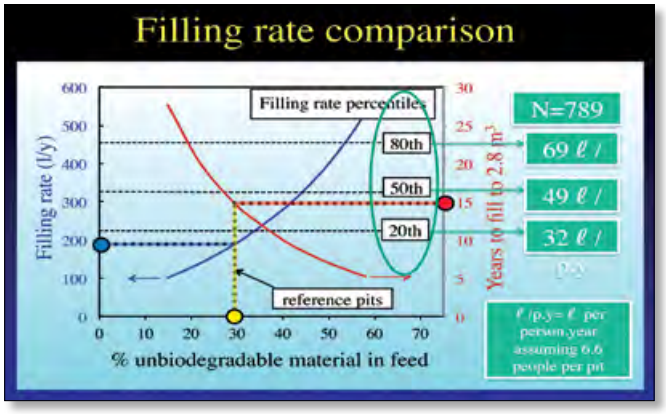
Modelling the filling rate of pit latrines

CJ Brouckaert, KM Foxon and K Wood

This presentation highlighted a simple material balance model, which represents faecal sludge as a mixture of biodegradable organic material, un-biodegradable organic material and inorganic material. Excreta (faeces and urine) that are deposited into a pit latrine are subject to biodegradation, which substantially reduces the volume that remains. However, matter that is not biodegradable also finds its way into pit latrines. The net filling rate is dependent on both the rate of addition of material and its composition. The model considers material found in a pit to be divided into two main categories; the so-called *fine sludge* is that portion that is visually approximately homogeneous, with a maximum particle size of about 1 mm; and a component made up of un-biodegradable household *coarse refuse* that has much larger particle size i.e. plastic bags, discarded cloth and household detritus. Since no biological transformations occur in the coarse refuse fraction, it accumulates with time in the pit and can be considered in isolation from the other material in the pit. The contents of a VIP have an aerobic surface layer, but anaerobic conditions prevail in deeper layers. Thus the exposed surface of pit contents, especially newly added material, will be subject to aerobic biological processes. As the pit contents are covered over and oxygen supply is limited, conditions in the pit become anaerobic, and anaerobic biological processes dominate. The distribution of material in the pit is determined by the entire history of what was disposed into it. This depends on the history of the users' behaviour, about which we have almost complete ignorance. Modelling the process therefore inevitably involves sweeping assumptions, such as considering the rate of deposition of material into the pit and its characteristics to remain constant for the entire period. For the pits studied, the model predicts that the filling time could have been extended from 15 y to over 25 y if all solid waste had been excluded from the pit.



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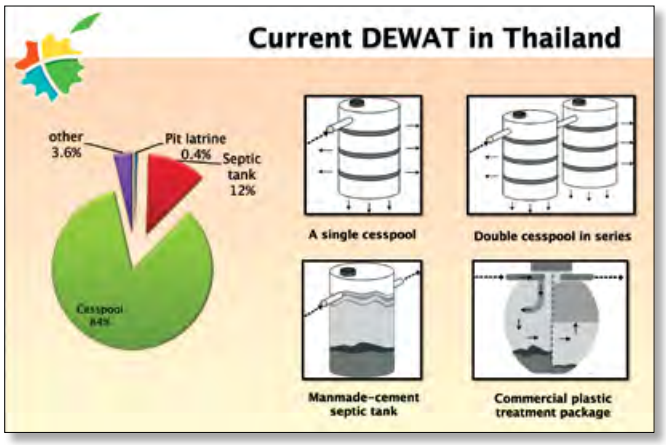
Accumulation rates of thickened-bottom sludge and its characteristics from water-based onsite sanitation systems in Thailand

Thammarat Koottatep*, Nawatch Surinkul*
and Atitaya Panuvatvanich*

This paper described accumulation rates of the thickened-bottom sludge and its characteristics. In emptying faecal sludge from any OSS, it has been widely recognised that the most difficult place to withdraw the sludge is from the bottom of the tank. These were analysed from samples taken from the conventional water-based OSS in Thailand: (1) a manmade-cement septic tank; (2) a single cesspool; (3) double cesspools in series; and (4) a commercial plastic treatment package. The results obtained from field investigations in 3 provinces demonstrated that the total solid (TS) concentrations of the mixture of supernatant and thickened-bottom sludge are in the range of 10 000 to 17 500 mg/l, while the TS of the thickened-bottom sludge could be at the concentrations of 40 000 to 220 000 mg/l. The highest TS concentrations were obtained from the samples of thickened-bottom sludge in commercial plastic units and contained relatively high fixed solids, possibly due to the relatively large amount of disposal of tissue papers. Likewise, VS contents in the thickened-bottom sludge of commercial plastic units were only 11% of TS whereas those in other OSS systems were in the range of 60 - 70% of TS. Considering sludge emptying frequency, the commercial plastic system requires emptying every 2.5 years, while an average frequency of once in 1.5 years is expected for the others. The accumulation rate of the thickened-bottom sludge does not depend on types of OSSs, but is rather dependent on land use and soil texture. The results of these findings could reaffirm the challenges in emptying sludge from OSS which require specific techniques for the thickened-bottom sludge with such unique rheological properties.



Contact details: *Thammarat Koottatep*, Nawatch Surinkul* and Atitaya Panuvatvanich*. *SERD, AIT, PO Box 4, Klong Laung, Pathumthani, 12120, Thailand*

Pour flush – a new sanitation paradigm in Africa, and implications for FSM

JN Bhagwan * and D Still **

People aspire to some form of flush sanitation for reasons of convenience, aesthetics and status. The enormous cost and high water demand of conventional full flush sewered sanitation makes this option prohibitive for many communities. However, pour flush does offer much of the convenience of full flush sanitation without the high cost. Sanitation practice differs fundamentally between South Africa and Asia. In South Africa (as in much of Africa) sitting and not squatting is standard, as is the use of paper rather than water for anal cleansing. Until now it has been assumed that due to these differences pour flush would not work in South Africa. In 2009, the WRC commissioned a research project to test the validity of that assumption.The study has resulted in the development of a new 1l pour flush pedestal, which was tested according to the internationally accepted MaP (Maximum Performance) protocol and then piloted and demonstrated in 22 households and one crèche. Over a two year period, monitoring has shown that there have been no technical or operational problems with the technology (even when newsprint is used for anal cleansing) and the user satisfaction has been high. This has proven that pour flush can indeed work in Africa, which potentially has major implications for FSM in areas where previously the pit latrine was considered the only sanitation solution. Experience to date with dry sanitation in South Africa has shown the many challenges which need to be addressed to support sustainability over the long term. User behaviour and attitudes, as well as a lack of understanding of the sanitation environment by planners and designers, has resulted in many interventions being in jeopardy. Challenges with dry sanitation:

- pits filling faster than design.
- access to pits is a challenge.
- pit de-sludging is expensive.
- no holistic management.
- focus on superstructure.

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Superhydrophobic materials for faecal sludge management

Chunlei Guo

The goal of the Grand Challenges Explorations (GCE) phase I project is to create a superhydrophobic (super water-repelling) material surface. The presentation demonstrated the successful creation of such a surface and it was shown to repel liquid and provide an essential element for anti-biofouling and faecal sludge management. A latrine trap door concept was discussed based on this material. The lab had pioneered a laser surface structuring technique which enabled regular materials to be made superhydrophilic (water bonding), regardless of their intrinsic wetting property. Based on this past experience, researchers set out to develop the counterpart technique of making a superhydrophobic surface. In this GCE project, successful creation of such a surface has been achieved. At the FSM2 Conference the superhydrophobic effects were demonstrated using the samples created. For example, when a drop of water is released above a surface treated with this method, the water droplet is repelled and bounces off the surface. The superhydrophobic surface has a self-cleaning and anti-biofouling effect. Traditional latrines used in most developing countries typically contain a squatting platform with an open hole beneath it. One major problem with all open pit latrines is that they allow airborne arthropods (flies) unfettered access to disease-carrying waste. A lightweight, spring-loaded trap door just beneath the squatting surface would provide this barrier. This presentation will discuss how a superhydrophobic material is essential in designing such a trap door.

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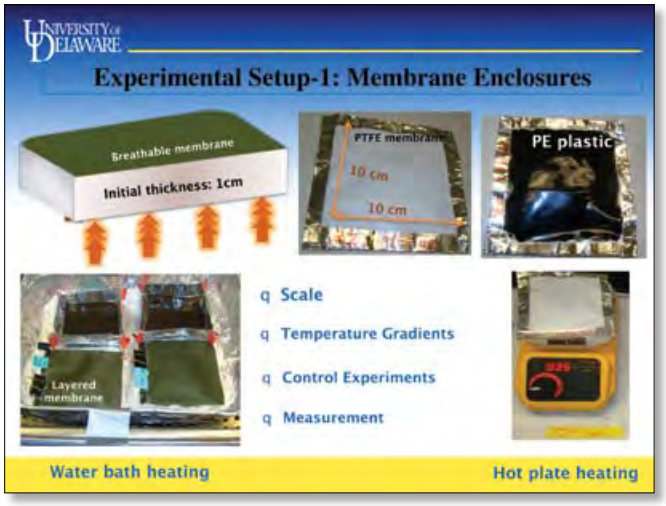
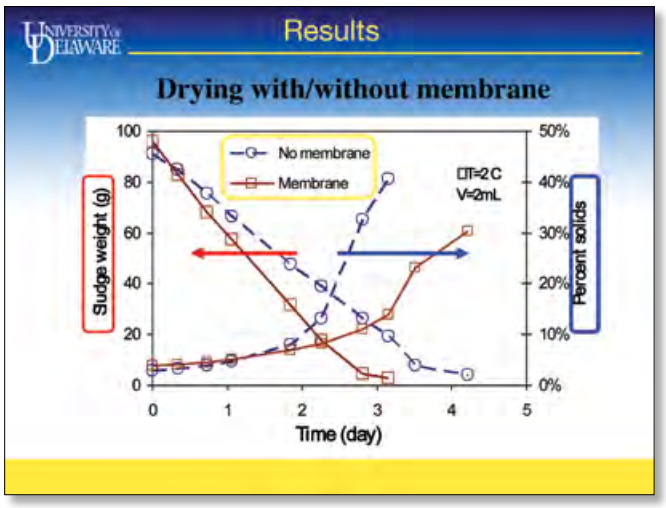
Breathable membrane enclosures for faecal sludge stabilisation

SK Dentel, S Marzooghi, and CJ Shi

This presentation reported on successful testing of breathable membranes for controlled stabilisation of sludge. These membranes are plastic materials that, due to their hydrophobic properties, do not allow passage of liquid water, or the contaminants in the water. However, water vapour can be driven across the membrane by a temperature difference–even a small one–which allows water purification. The research reported here applies these breathable membranes to faecal sludge treatment, to protect surrounding groundwater or floodwaters from contamination, while allowing the sludge to condense and stabilise. The membrane is used under, around, or perhaps over the faecal material (as in a composting process) to improve the drying and thus disinfection of the material. The faecal sludge warms as it decomposes–possibly by added solar or air temperature means as well–which drives water, and only water, out of the sludge through the membrane. Drying inactivates pathogens in sludges, so that the material can be more safely removed from the modified privy. Some breathable membranes, such as Tyvek, may be strong enough to make removal as simple as pulling out the entire membrane enclosure. The breathable membrane is unlike either the membranes used for water filtration or ultrafiltration, or the membranes used in geotextiles for dewatering. Instead, a breathable membrane has pores that fill only with air or water vapour, because the material is hydrophobic (non-wetting). It is thus much less susceptible to fouling or scaling. Temperature, rather than pressure, drives the water vapour through the pores, in the direction of warmer temperature to cooler due to differing vapour pressures. The results so far include different membrane types, temperature differences, and enclosure configurations. The research report will conclude with scale-up plans and possible advantages and disadvantages of this privy modification.





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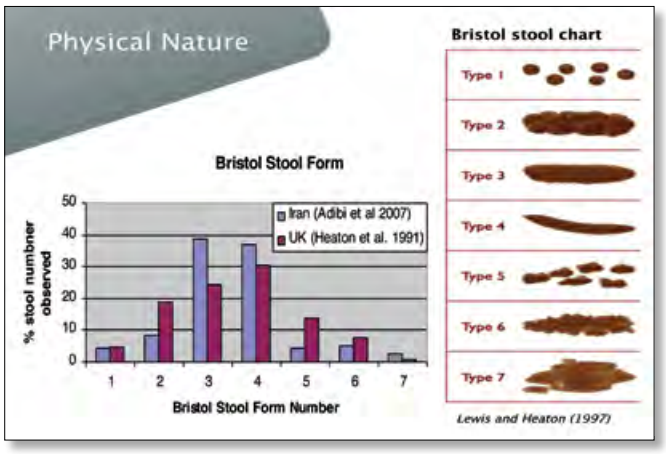
The nano membrane toilet

AH Parker*, B Jefferson*, EJ McAdam*, RA Dorey*, AJ Kolios*, SF Tyrrel*, PJ Longhurst*, S Bolton*, G Leighton*, RWA Franceys*, E Cartmell*

This presentation discussed the proposed concept for a Nano Membrane Toilet, by a team at Cranfield University. The toilet will be able to treat human waste on-site without external energy or water, allowing it to be safely transported away and potentially reused. Current toilet designs are not meeting the needs of 2.6 billion people on earth who currently lack access to safe and affordable sanitation. Many of these also have non-existent or unreliable water, sewage and electricity supplies. This toilet will accept faeces and urine as a mixed stream. Volume reduction of urine and faeces will be undertaken using dense polymeric membranes that enable extraction of the water content as a vapour through the membrane wall. These membranes will be used to thicken the sludge to a target solids content of between 20% and 25%. The membrane wall comprises a low glass transition temperature (GTT) dense polymeric structure which enhances the membrane's permeability for water vapour. These membranes separate water vapour through a solute-diffusion mechanism which requires only a very small vacuum pressure to be applied. Since the membrane is non-porous, the resultant distillate (transported water vapour) will be pathogen-free water. The resultant sludge will move downwards through the toilet under gravity before encapsulation as a briquette with fuel or soil nutrient potential. Overall the output from the toilet would be pathogen-free water and sludge briquettes for combusting or applying to land as a fertiliser.



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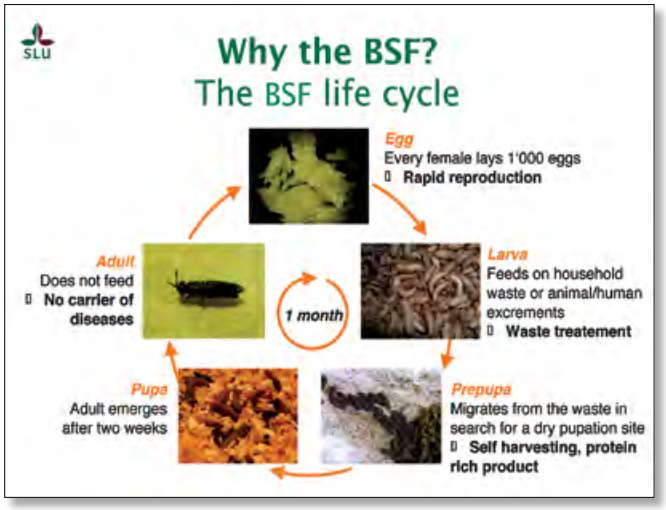
Monday 29 October 2012 / Session C3: Breakaway 2

The potential of treating human faeces with black soldier fly larvae

C Lalander*, S Diener**, M Magri*, C Zurbrügg** and B Vinnerås*,***

In this study, the potential of using black soldier fly larvae for treatment and valorisation of faecal sludge in low and middle-income countries was investigated. In low and middle-income countries, collection and treatment of faecal matter is a costly process and its uncontrolled disposal often creates health risks and leads to environmental pollution. The larvae of the black soldier fly, *Hermetia illucens* L. (Diptera, Stratiomyidae) devour any form of decaying organic matter and in the process reduce the volume of the matter considerably. It has six larvae stages, in the last the so-called prepupa leaves the feeding material in order to find a dry and dark place to pupate. The prepupae have been shown to be a possible alternative to fish meal as animal feed. On dry matter basis, one tonne of faeces can be converted into 100 kg of prepupal mass. The residue can, after appropriate treatment, be bagged and sold as high value fertiliser. Microbial reduction studies revealed that the larvae accelerated the inactivation of *Salmonella* spp.; however their effect on *Enterococcus* spp. and the eggs of the helminth *Ascaris suum* was negligible. The prepupae were demonstrated to contain some of the pathogens. Solar drying and boiling are potential treatment methods. For the residue – albeit demonstrating somewhat lower concentrations of some of the pathogenic organisms evaluated, other organisms remained unaffected by the treatment – additional sanitisation is paramount, *e.g.* thermophilic compositing or urea treatment. It is concluded that BSF is a promising technology for the conversion of faecal matter into valuable products with certain precautions concerning hygienic aspects.

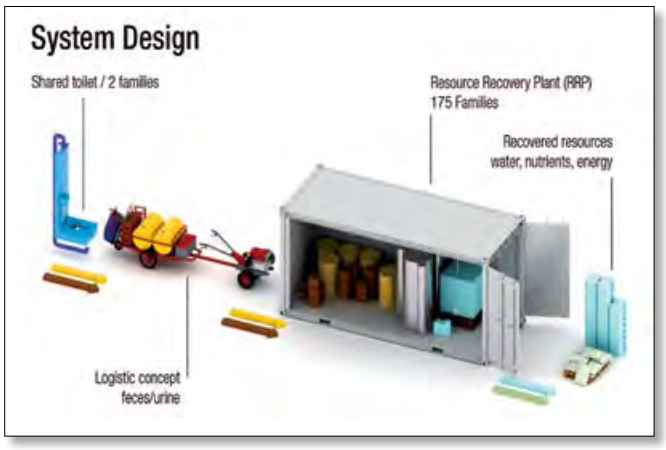


Contact details: *C Lalander*, S Diener**, M Magri*, C Zurbrügg** and B Vinnerås*,***. *Department of Energy and Technology, Swedish University of Agricultural Sciences, Box 7032, 75007 Uppsala, Sweden. ** Swiss Federal Institute of Aquatic Science & Technology (Eawag). ***National Veterinary Institute (SVA)*

Diversion for safe sanitation: a new approach to sanitation in informal settlements

Tove A Larsen*, Harald Gründl**, Christoph Lüthi* and Eberhard Morgenroth*

This project is part of the Reinvent the Toilet Challenge (RTTC), a call from the Bill & Melinda Gates Foundation (BMGF). *Diversion for safe sanitation* is based on two main elements: diversion of urine and faeces at source for resource efficiency, and combination of scales for rapid implementation of family toilets. The objective is to develop an attractive grid-free dry diversion toilet (separately diverting undiluted urine and faeces), which provides water for flushing, comfortable personal hygiene (for washers and for menstrual hygiene), and for hand washing. A service concept for linking the family scale to a community scale Resource Recovery Plant as well as a business model with maximum profit for the local community is set-up. The service including the entire sanitation value chain shall be provided as a profitable business with total fees of 5 c/person/d. The toilet has been designed to fulfil all objectives, allowing for local rotational moulding of all parts. It can be installed as a shared toilet for 2 families in any available super-structure or as an in-house private toilet. The water is recovered on-site in a maintenance-free ultra-filtration unit followed by on-site electrolytic chlorine production. Total energy consumption is 4-8 W/toilet, provided by a small solar panel. The low energy consumption is only possible because more than 95 % of urine and faeces are diverted at source directly towards resource recovery. A service concept links the family toilet to a Resource Recovery Plant, conceptually set up for 175 families. The service concept is based on the collection of urine and faeces from each toilet twice a week. Based on smart design and standardisation, the service concept is hygienically safe and in densely populated informal settings, the collection service can be provided at around 1 c/person/day. Resources can be recovered from urine and faeces by a large number of processes.



Contact details: *Tove A Larsen*, Harald Gründl**, Christoph Lüthi * and Eberhard Morgenroth*.*
**Eawag, Ueberlandstrasse 133, 8600 Duebendorf, Switzerland/Europe; Tel: +41 58 876 5039; Fax: +41 58 876 5389. **EOOS, Zelinkagasse 2/6, 1010 Vienna, Austria/Europe, design@eoos.com*

The earth auger toilet: innovation in waterless sanitation

Marcos Fioravanti*, Charles L Henry**

The goal of this project is to commercialise a series of affordable urine diverting dry toilets (UDDT) that have functional and comfortable features designed to increase the acceptability of dry sanitation. The various models accommodate both high-density and rural communities, and can fit the financial constraints of low-income residences. These toilets differ in price and number of accessories, with the following basic features:

• Low cost (beginning at $150) • No water required for flushing • No energy required • Urine diverting system • Little odors or fly problems • Safe and comfortable to use. • Easily operated and maintained • Cheaply and easily repaired (if necessary) • Creation of compost (from excreta and dry material) and urine harvesting • Pedal operated sawdust flushing • Pedal operated mixer-auger (to process excreta + sawdust) • Pedal operated flushing (to avoid visual contact)*.

* Only in the Gran Taladro prototype.

The “Taladros” have foot actuated dry flush, sawdust delivery and compost mixing and movement. Excreta handling is not needed; the whole process is pedal-operated until harvest, when material is automatically stored in buckets. Storage time in buckets is dependent uponthe number of users, with detention time required for compost stability and pathogen kill prior to use as a soil amendment.

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Tuesday 30 October 2012 / Plenary Session P2: Main Hall

Managing Your Everyday Shit: Systems Approach for Faecal Sludge Management

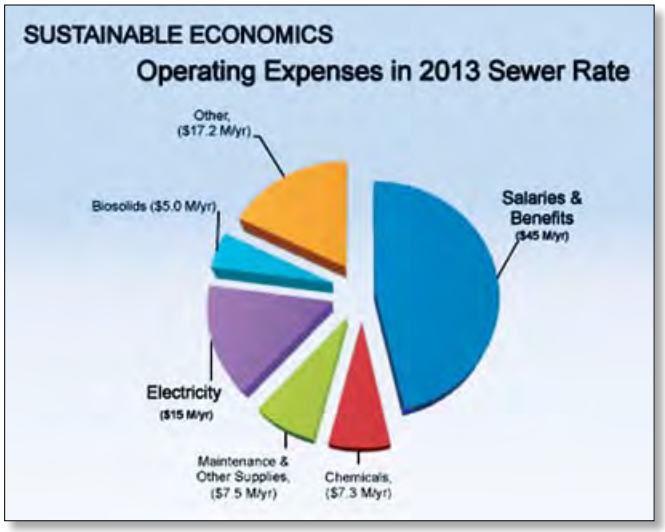
Linda Strande
Programme Leader of Excreta and Wastewater Management, EAWAG/SANDEC

Historically, waterborne, sewer based systems have been seen as the only viable, long term solution to fulfill sanitation needs. But this is obviously not working, and we see the result of this everywhere. In the last 10 or 15 years, worldwide the focus has started to shift, and people are starting to consider onsite or decentralised technologies as not only being long-term viable options, but possibly the most sustainable alternative. The reality is that billions of people in Africa, Asia, and Latin America are currently served by onsite sanitation technologies. Management of FS from these systems, is obviously going to remain an issue in the future. Onsite sanitation technologies can be the most sustainable option, if they are managed properly, throughout the entire FSM service chain. FS management is very different to sewer based, because one has to consider the entire service chain. FS all about managing people, interactions at every step, from household level, collection and transport, treatment, final disposal or end use. The approach to fulfill sanitation goals, is definitely not just about building onsite technologies, for example a pit latrine or a septic tank. It is critical to determine what will happen when the system is full, and what the final end use or disposal option is, and then design backwards to meet treatment objectives, and fulfill your client or stakeholder needs. To improve a complete FSM service chain, it is important to look at each component separately and individually, and most importantly, how they all integrate together. Sandec has almost 20 years research experience in FSM, and has worked together with many people at this conference. The program was started by Martin Strauss who was very innovative and forward thinking in this field. The success of Sandec is our collaborative research partnerships.

Evolution of a regional wastewater management system: matching decisions to capacity

Pam Elardo
Director, Wastewater Treatment Division, Seattle

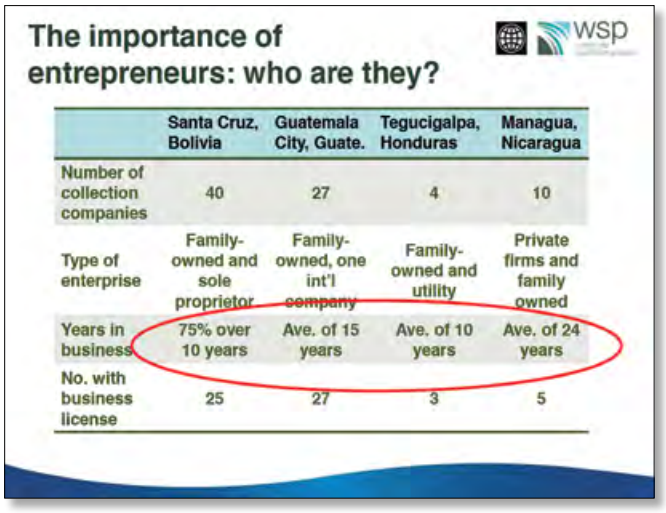
Elardo's experience spans the extremes of the faecal management spectrum: from very coentrealised to extremely decentralised. She runs one of the largest regional public wastewater management utilities in the United States as director of the Wastewater Treatment Division in metropolitan Seattle. On the opposite side of the scale, she is the volunteer President of the Living Earth Institute or LEI, a non-profit organisation that works in some of the most remote impoverished areas of the world, with very little established infrastructure, very few toilets and rare access to clean water. The differences between the two worlds are stark; however, the principles of sustainability that make projects successful apply to both. The Living Earth Institute- LEI was started in 1999. Its mission is to empower communities to protect their health and environment through the sustainable use of water resources. The organisation focuses on the key measures for sustainability in all aspects of their work. "Sustainability" is defined as implementing technical, financial, operational elements that allow systems that we invest in today to provide services for the community served long term. The presentation focused on a case study of Seattle. Three main objectives are discussed in detail: Remove contact between people and waste; Employ appropriate treatment technologies; Reclaiming resources from wastewater. The presentation did not advocate for any particular technologies, but rather discussed a series of objectives that applied to, and still applies to, Seattle throughout the history of faecal management. The regional wastewater system serves 1.5 million customers, with over 600 employees providing service 24 hours per day/7 days/week. The system spans over 500 km of pipes and 5 treatment plants.



Living without Sanitary Sewers in Latin America

Glenn Pearce-Oroz
Regional Team Leader, World Bank - Water and Sanitation Program, Peru

This presentation reported on the major challenges and the opportunities that lie ahead in faecal sludge management and summarised the findings from four case studies that describe the current and potential market for sludge removal, collection, and disposal in peri-urban areas in four Latin American cities. These areas typically struggle with high population density, insufficient land use planning, high citizen insecurity, and low coverage with basic services. The report demonstrated how technical, financial, environmental, social, regulatory, political, and institutional factors interact to create supply and demand in four markets where coverage with sanitary sewerage services is below the regional average, namely: Santa Cruz (Bolivia), Guatemala City (Guatemala), Tegucigalpa (Honduras), and Managua (Nicaragua). Even though households in the four areas studied have onsite sanitation systems (latrines and toilets), faecal sludge and excreta often drain into the streets, and there is no control or treatment of the sludge, posing a risk for public health and the environment. In recent years, these cities have grown at such a rapid rate that on-site sanitation has become an increasingly popular solution in peri-urban areas and the faecal sludge market is going to continue to grow in the future. Expanded coverage with sanitary sewage services, as well as the adoption of alternative on-site solutions in particular, will hinge on a number of factors. To begin with, it will be necessary to have the proper infrastructure and ensure that installations do not become foci of infection. In addition, there will need to be services to certify that the sewage is being properly managed. In addition to covering these points, the present report has sought to contribute to the search for integrated, sustainable solutions that take into account the economic, social, political, and environmental dimensions of on-site sanitation.



	Santa Cruz, Bolivia	Guatemala City, Guate.	Tegucigalpa, Honduras	Managua, Nicaragua
Number of collection companies	40	27	4	10
Type of enterprise	Family-owned and sole proprietor	Family-owned, one int'l company	Family-owned and utility	Private firms and family owned
Years in business	75% over 10 years	Ave. of 15 years	Ave. of 10 years	Ave. of 24 years
No. with business license	25	27	3	5

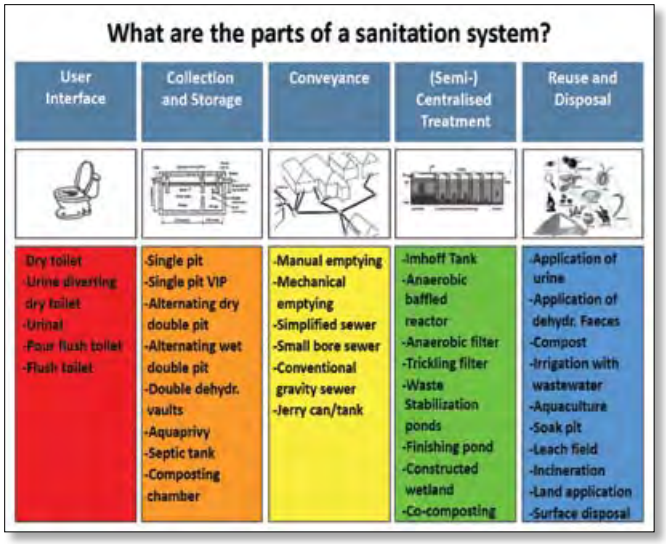
Health and exposure assessments as tools for faecal sludge management

Thor-Axel Stenström
Swedish Institute for Infectious Disease Control

At the outset the presentation provided an overview of the 2006 WHO Guidelines for the safe use of wastewater, excreta and grey water. Cost-effective strategies for controlling negative health impacts were summarised to include the following:

- Treatment of wastewater, excreta and greywater is aimed to reduce the environmental load of contaminants.
- Crop/produce restriction is used to minimize health risks to product consumers.
- Waste application techniques (e.g. drip irrigation) and withholding periods aim to reduce contamination.
- Exposure control methods prevent environmental contamination from reaching exposed groups.
- Vector control reduces exposures for workers and local communities.

A background on the aspects that should be covered in a Sanitation Safety Plan (SSP) was given by the presenter. Some of the items included that a SSP should provide a framework for assessing, managing and monitoring risks along the sanitation chain. It should take into consideration multiple routes of exposure and multiple exposed groups in relation to microbial and chemical safety. The SSP should expand the systematic approach to include downstream health and environmental effects. In relation to management and exposure the SSP should link to CCPs in an incremental management approach and should account for the fragmented sectoral responsibilities, the diverse decision-making process and the involved implementing agencies. In summary any sanitation system needs to be addressed in a system perspective from "the users" to the reuse or disposal. Health and nutritional benefits are depending on management and practices. A full understanding of the exposure will allow you to mitigate risks and maximise benefits. An integrated approach accounting for WASH in the households and the communities will maximise benefits.

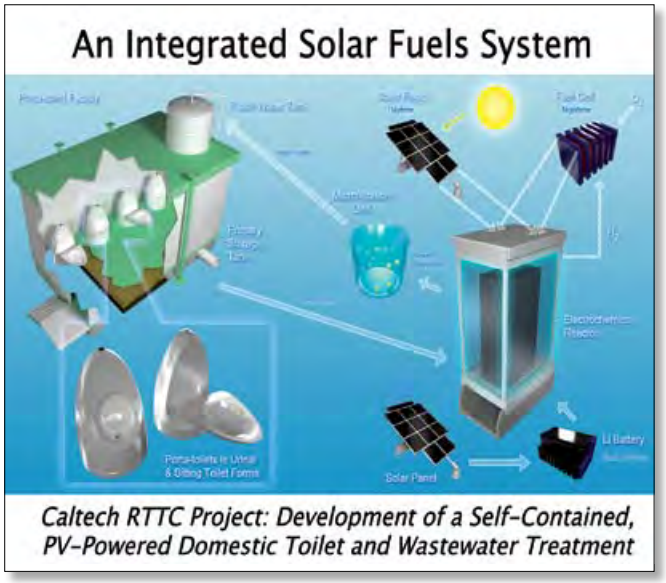


Tuesday 30 October 2012 / Session A4: Main Hall

Solar-powered approaches to human wastewater and sludge treatment

Michael R Hoffmann*, Kangwoo Cho, Daejeon Kwon, Yan Qu, Asghar Aryanfar, and Hao Zhang

This presentation provided an insight into a project that is part of the Reinventing the Toilet Challenge (RTTC) initiative, with support from the Bill and Melinda Gates Foundation. The initial phases of design, development, and performance testing of a comprehensive approach to human faecal solids control and liquid waste treatment have been completed. The treatment scheme incorporates sludge disinfection, treatment, and volume reduction. The basic solar toilet system has at its core photovoltaic-powered (PV) electrochemical chemical reactors that generate H_2 as a potentially useful by-product obtained during anoxic wastewater and faecal matter treatment including the complete disinfection of the total cultural bacteria initially present. The system has been designed to be free of an electrical grid or from subsurface urban infrastructure. The solar toilet and associate waste treatment system includes western-style and conventional squat toilets, a waterless urinal for men, a septic waste holding tank, solar-powered electrochemical reactors, a post-reactor storage tank, an integrated hydrogen fuel cell, a Li-ion or conventional battery array for solar energy storage, as well as a membrane microfiltration unit. In addition there is a flushing recycled water storage tank containing the fully treated water from either a single family toilet unit or upon expansion in size to handle the daily wastes of 500 people with a predicted break-even operating cost when powered by a PV array in which energy is stored for use throughout 24 hours of continuous operation. The concept has been tested at the bench-scale and also at the prototype scale. Results of key laboratory investigations and the complementary field testing of actual wastes were highlighted in the presentation.



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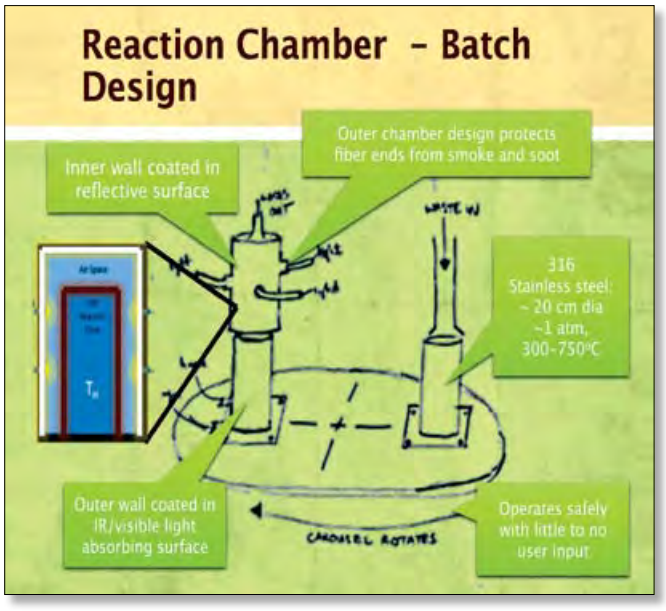
Solar-driven thermal toilet with Biochar production

Karl G Linden*, Al Weimer, Scott Summers, Al Lewandowski, Rita Klees, Ryan Mahoney, Richard Fisher, Tesfa Yacob

This presentation outlined the approach and theoretical basis for the Solar-Biochar Toilet concept. More specifically, the technological components of the solar collector, the transmission of solar energy via a fibre optic cable, and the design of the reaction chamber were discussed. The Solar-Biochar Toilet is a state-of-the-art project incorporating the latest scientific advances in the areas of solar thermal processes, ultraviolet/thermal driven disinfection, and hydrothermal biochar production and utilisation. The University of Colorado Boulder is working to explore fundamental research questions regarding applications of solar-driven hydrothermal pyrolysis to mixed human waste, without need for intensive pre-drying, to produce a char that has advantages in soil applications for agriculture. Research will provide the scientific basis for the Solar-Biochar Toilet system to safely generate valuable end products that could increase the toilet's use and offer households and/or entrepreneurs a valuable human waste-derived product for income generation.



Contact details: *Karl G Linden*, Al Weimer, Scott Summers, Al Lewandowski, Rita Klees, Ryan Mahoney, Richard Fisher, Tesfa Yacob University of Colorado*
Professor, Department of Civil, Environmental, and Architectural Engineering, University of Colorado Boulder USA. Tel: +1 303-492-4798

Faecal sludge disposal in situ - a solar toilet solution for dry countries/sunny zone

Jing Ning

This project demonstrated a solar toilet capable of disposing faecal sludge in situ. The system includes a solar-energy collection and transforming unit, a faecal sludge disposal in situ unit, and a self-supporting flushing unit which comprise a waterless toilet.

The prototype makes use of a sun-tracking thermal system. Media oil is circulated by the energy collected in the disposal board. The heating board is heated by the oil which then raises the temperature of the disposal-pot. The waste disposal unit is similar to a large-size rice cooker. The disposal processing steps can be understood as: firstly, heating to 100 degrees C which leads to evaporation, resulting in the waste being dewatered; secondly, as temperatures continue rising to 130 - 150 degrees C, pathogens will be removed from human waste; thirdly, the disposal-pot is cleaned and made ready for re-use. The output of the process, waste powder, is a very good organic fertilizer. The Solar Toilet incorporates waterless equipment in which flushing is performed by a self-supporting water cycle program. Specifically, urine is collected and processed as "grey water". The vapour, evaporating from waste disposal, is processed as "white water". Urine-flushing will use 100ml "white water". The toilet bowl flushing, after defecation, will first use 0.5 litres "grey water" and then 100ml "white water". The challenge of the flushing operation is to leave the toilet bowl clean after defecation using only one flush, as a second flush would burden the limited disposal capability. This was solved using a high-pressure car-washing pump to provide 100psi pressure for flushing.

The Solar Toilet seems to meet all the requirements suggested by the "Reinvent the Toilet" programme: "off the grid, inexpensive, recovering resources, and removing pathogens".

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Inactivation of helminth in a solar concentrator

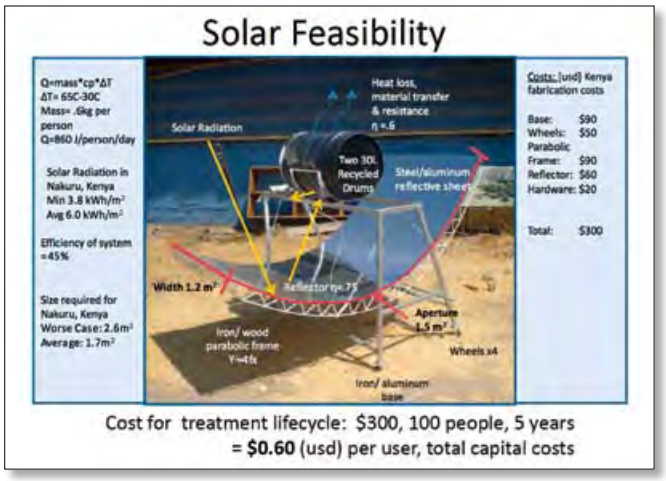
Andrew M Foote[1], Emily Woods[2], Fernando Fredes[3]

The goal of this project was to evaluate the effectiveness of a solar concentrator in inactivating helminth in faecal matter and in doing so, meet World Health Organization (WHO) guidelines for safe disposal and reuse of faecal matter.

More than 1 billion people worldwide are infected with helminths. Typical pit latrines and composting conditions do not inactivate helminths in faecal matter effectively. By concentrating solar energy and reaching pathogen inactivation temperatures (50°C and higher), a solar concentrator, with projected capital costs of $0.30 per person per year, has the potential to inactivate helminths in faecal matter. Inactivation was assessed by evaluating the viability of *Toxocara canis* eggs. *T. canis* is a helminth in the same taxonomic order as *Ascaris lumbricoides*, which is a WHO indicator for safe faecal disposal and reuse. Three trials were conducted from December 2011 through February 2012 in Santiago, Chile.

The first two trials evaluated *T. canis* viability daily. To calculate the inactivation rate for the solar concentrator unit, the third trial evaluated *T. canis* viability hourly. In each trial, *T. canis* eggs were isolated from canine faecal matter, concentrated, placed in semi-permeable tea bags (1 500 eggs each) and inoculated into 40 litres of fresh canine faecal matter. *T. canis* eggs were inoculated into two control conditions: indoors in the dark, and in a mimic pit latrine.

At the end of each trial, eggs were incubated and classified as viable if they contained a motile larva. The results suggested that a solar concentrating unit can be used to rapidly inactivate helminths in faecal matter, and therefore, faecal matter treated by a solar concentrator can be safely disposed and reused on edible crops.



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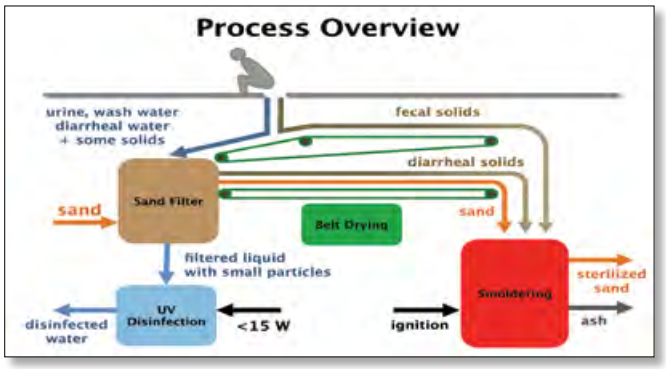
An Integrated Approach for Rapid Disinfection of Human Waste Based on Drying/Smouldering of Solid and Sand Filtration/UV Disinfection of Liquid Waste

Zachary Fishman*, Young Mee T Jung*, Paolo Pironi#, Michal Krajcovic#, Samuel Melamed*, Meagan Webb*, Jose L Torero#, Jason I Gerhard§, Levente L Diosady*, Yuri Lawryshyn*, Elizabeth Edwards*, Mark T Kortschot*, Yu-Ling Cheng*†

This presentation provided highlights of a study that adopts a unit operations approach towards human waste disinfection, taking into consideration the conditions in developing world settings. When fully-developed, the process should require only materials that are readily available and equipment that can be maintained locally. Liquid and solid streams are passively separated at source. A surrogate faeces composition that is matched to literature values for caloric content and moisture content of faeces was formulated and used in these studies. Solids are flattened, and moisture content is reduced on a roller/belt assembly. The solids are then mixed with sand and the organics and pathogens are destroyed via smouldering combustion. The liquid stream, including solid contaminants from diarrhoea or wash water used for personal hygiene, is filtered in a sand filtration unit, and the filtrate is subsequently disinfected by UV radiation. Filtration results were presented in the form of drainage time and solid removal efficiency as a function of sand particle size, bed height, and loading per use. Computational results that give the spatial distribution of UV intensity based on geometric factors, and dose distribution based on flow characteristics/ residence time distribution and UV intensity distribution were presented. These results demonstrate that in principle, UV doses that are sufficient for killing common microbes in diarrhoea and faeces can be achieved with 15 watt UV lamps.



Contact details: *Zachary Fishman*, Young Mee T Jung*, Paolo Pironi#, Michal Krajcovic#, Samuel Melamed*, Meagan Webb*, Jose L Torero#, Jason I Gerhard§, Levente L Diosady*, Yuri Lawryshyn*, Elizabeth Edwards*, Mark T Kortschot*, Yu-Ling Cheng*†. *Centre for Global Engineering and Dept of Chemical Engineering and Applied Chemistry; University of Toronto, Toronto, CANADA M5S 3E5. # BRE Centre for Fire Safety Engineering, University of Edinburgh, Edinburgh, United Kingdom, EH9 3JL. § Dept of Civil and Environmental Engineering; University of Western Ontario; London Ontario; CANADA N6A 5B8*

Tuesday 30 October 2012 / Session A5: Main Hall

Vortex bioreactors for the processing of faecal sludge and waste water in decentralised waste water treatment systems (DEWATS)

M Allen*, S Thomas*, P Rooks*, S Ali*, F Rudin*, L Herrera**, T Ali**, F Khan** and P Goddard**

The demand for reliable, efficient and low-cost wastewater treatment systems is increasing around the world, especially in densely populated urban regions. DEWATS endeavour to deliver state-of-the-art water treatment outcomes with small foot print, low maintenance, and low-cost equipment. Hand/bicycle driven vortex bioreactors are cheap to construct, can efficiently separate liquids and solids, and are highly versatile. A pilot-scale device has been developed that can reduce viable counts in microbial contaminated water by 99.85% within 10 minutes, even under conditions that still remain to be optimised. Using a purpose built scaled-down, desk-top, closed loop vortex bioreactor with a working volume of 7 litres, viable *E. coli* counts were reduced from 106 per ml (i.e. nearly 1010 cells in total) to zero within 15 minutes; 99.85% were destroyed within 10 minutes. The reactor was powered by means of a simple electric drill at setting 3 of a possible 15 speeds (1 lowest, 15 maximum) and a standard 5 blade model boat impeller. The viability of *E. coli* in the reactor without a lytic agent (either blank beads or no beads at all) remained unaltered, proving that the enhanced contact between beads and bacteria induced by vortex flow is responsible for the bactericidal capabilities of the system. The vortex bioreactor successfully and reliably destroyed E. coli upon repeated exposure to increasing amounts.

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NEWgenerator[tm] membrane biotechnology for the recovery of nutrients, energy and water from human wastes

Daniel Yeh*#, R Bair*, O Ozcan*, M Woodham*, J Calabria*, L Haralampieva* and H Jean *

This presentation discussed a GCE Round 7 Phase I project, which involves the development of the *NEWgenerator*[TM], a decentralised anaerobic treatment process to process wastewater and faecal sludge generated by a small community. The presentation reviewed the theoretical potential and challenges of energy and nutrient recovery from human wastes as well as described the membrane biotechnology behind the *NEWgenerator*[TM]. The aim of this technology is to reduce or eliminate energy required to treat waste, and instead to generate surplus energy from waste treatment, with a focus on resource recovery (energy via methane, N, P and K for fertilizer, and clean water) rather than removal. The *NEWgenerator*[TM] is based on the AnMBR, which synergistically combines anaerobic digestion with low pressure membrane filtration. The UF membrane used has micropores small enough that practically all pathogens are removed (four log removal for virus, six log for bacteria and eight log for helminths). The methane can be used as a clean fuel for cookstoves or other heating needs, while the disinfected, nutrient-rich clean water can be used directly for irrigation (fertigation), satisfying the large water and fertilizer demands of agriculture. As a technology, the AnMBR has been used to treat industrial and agricultural wastes in developed countries, and is well-positioned to be an important tool for global sanitation and resource recovery from wastes. With the *NEWgenerator*[TM], the goal is to develop an off-grid, simplified, robust and passive AnMBR system that is adaptable to a variety of physical and cultural settings in the developing world. For example, the *NEWgenerator*[TM] can be coupled with a latrine, or a faecal sludge pit emptying device, to provide onsite recovery of resources from human wastes.

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Research on self-sustained etoilet for households/ urban-semi urban public/ community sanitation

A MS Vinod* and B Bincy Baby**

The universal challenge of providing affordable toilets is often hindered by the trade-off between cost and the functionalities to ensure three critical issues,beinga) cleanliness, b) conservation of resources, and c) sustainability of toilets. In pioneering electronic toilets, this research has identified these above critical issues as universally prevalent, irrespective of communities or geographies or demographics. This is an imperative since it has a direct bearing on the health of communities. Hence, it is proposed that the grant be used for initiating research activities in areas where the outcomes shall be in favour of providing sustainable solutions for the above three critical issues. The design of the research is to develop sustainable solutions for the above cited areas, which can be used effectively in households, slums or in urban/semi urban locations and cities to benefit the city dwellers and the large floating populations. Hence the universality of the solutions will be highlighted as an important outcome of this research. The research aims to provide affordable sanitation that ensures a clean and hygienic environment while recovering recyclable components. About e-Toilet:

- Compact Design: requires just 45 sq. ft (3.71 sq. m.) of space to set up.
- Integration with City's power distribution system or works on solar energy.
- Conservation of valuable resources.

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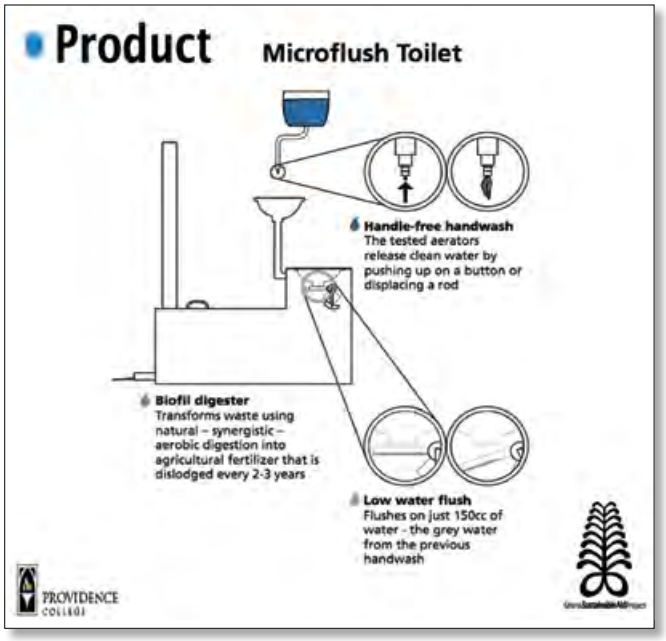
Tuesday 30 October 2012 / Session A6: Main Hall

The microflush/biofil system: results to date of prototype installations in Ghana

Stephen Mecca*, Hannah Davis** and Alyssa Davis***†

This paper provided an overview of the Microflush/Biofil (MB) system, including the combination of two technologies to produce field ready prototype toilets and the results of a 15 month operation of three different models: 4 household single-stall toilets, a 5-stall school model and a 10-stall public toilet facility. A single stall MB toilet typically serves as many as 30 users per day and is dislodged every 2-3 years. The toilet flushes on as little as 150 cc of (hand wash) water and bio-digests waste in an aerobic process using both micro- and macro-organisms. Advantages of this combined technology in sanitation have already been observed, as well as user acceptance and appeal, absence of flies and odour and affordability. Data confirming expectations in these areas as well as new findings that relate to the design of next generation MB systems will be presented along with some unexpected but solvable challenges that have been observed. The tasks and issues of scaling the technology were also discussed. Working with the MB toilet manufacturer, Biofilcom, the Ghana Sustainable Aid Project is hoping to demonstrate and advance this approach in a 400 unit community-wide implementation of MB toilets during the next two years.



Contact details: *Stephen Mecca*, Hannah Davis** and Alyssa Davis***†. *Professor, Department of Engineering-Physics-Systems, Providence College, 1 Cunningham Square, Providence, RI 02918 USA; Tel: 401 865 2099; Fax: 401 865 1438. **New York University, Tisch School, Interactive Telecommunications ***The Cooper Union, Albert Nerken School of Engineering. †The authors are members of the Ghana Sustainable Aid Project*

Floating treatment pods for lake communities

Irina Chakraborty, Wiley Jennings, Puthea Khon, and Taber Hand

This presentation provided an overview of an individual household wastewater treatment system that uses floating "pods" containing common water hyacinth (*Eichhornia crassipes*) and associated mesocosm biota that has been developed. Floating villages, as in Tonle Sap Lake, Cambodia, provide a unique challenge to address community sanitation needs. Residents live in floating houses, which move horizontally and vertically on the lake with changing seasons and water levels. The vast majority of households defecate directly from their houses into the surrounding water. As a result, water-borne diseases are widespread, and child mortality is high in the under-five age group. These pods are designed to receive faecal matter from households and sequester it while pathogen numbers are reduced through a combination of biological and physical processes. Having demonstrated the ability of the pods to significantly reduce E. coli (an indicator bacterium) levels under controlled conditions with municipal wastewater, tests are now being conducted with floating households. The goal of implementing treatment pods is to improve ambient water quality in the villages to a level where it is safe for recreational and other non-potable uses. A weekly survey is used to gauge the impact of pods on the health of 0-10 year olds in the village.

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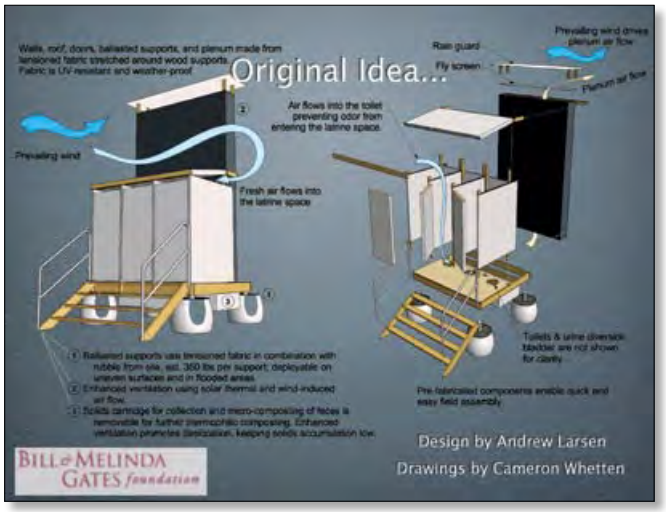
Five-toilet composting system array in peri-urban slums in Haiti - A report on progress

Andrew Larsen* and Andreas G Koestler, Ph.D**

This study investigated composting in-situ using multiple toilets in an array in a slum area of Port-au-Prince, Haiti. The presentation reports on the design, implementation and lessons learned. High temperatures are achieved in the location where pathogen-containing faeces are originally deposited. There is no handling of the material until after these temperatures have been achieved, and no excreta come into contact with the ground. Ventilation is driven by a Venturi, created by wind flowing over the top of the central ventilation plenum which is 14'-6" (4.5 m) off the ground. This plenum is much higher and has a much greater flow area, as well as a much larger surface area for solar gain (for thermal-driven air flow) than regular VIP-style vent pipes. These factors greatly increase the passive air flow through the system. Air is drawn in from intake vents in the Compost Bin/ Support so the position of the toilet lid has no bearing on the requirements for air flow. Odour control is both by the air flow proceeding up the plenum and the position of the toilet lid, which is designed to close on its own after use. This enhanced use of passive ventilation works for both the design described and, in future, the design in which faeces are desiccated and urine diverted at the toilet. Urine-diversion proved too difficult at this time and a ready source of composting substrate was available, which has previously been proven to be effective for use in high-temperature composting in Haiti.



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***Fontes Foundation, Bernhard Herres vei 3, 0376 Oslo, Norway. Tel: +47 90 75 28 56*

Tuesday 30 October 2012 / Session B4: Breakaway 1

Urine fertilizer for vegetable production – a case study in Nepal and Ghana

*Surendra K Pradhan[ab], Philip Amoah[b] Ram Chandra Piya[c], Helvi Heinonen-Tanski[a]

This presentation focused on the experimental demonstration of the use of urine, wood ash and poultry droppings (PD) as a fertilizer in central Nepal and in Accra, Ghana. Eco-toilets (human urine and faecal matter collected separately) are one of the best ways to solve sanitation problems, and this practice also improves the environment and increases the food production. In Nepal, fertilizer value of urine+ash was compared with animal manure and no-fertilization in the cultivation of radish, potato, broadleaf mustard, cauliflower and cabbage. The urine + ash or manure fertilized plots received 54 kgN/ha for radish, 51 kgN/ha for potato, 81 kgN/ha for broadleaf mustard and 77 kgN/ha for cabbage and cauliflower. Similarly in Ghana; urine was compared no fertilization and urine + PD (poultry dropping) was compared with NPK (mineral fertilizer)+PD as a dose of 121 kgN/ha. In Ghana, urine produced 1.2 ton/ha more cabbage head biomass compared to no fertilization and urine+PD produced 0.82 t/ha more cabbage head biomass compared to NPK+PD. Furthermore, in Nepal,N-fertilizer value of 4 liters urine is equal to the 1 kg of dry manure and in Ghana N-fertilizer value of 2 liters of urine is equal to 1 kg of poultry droppings. In conclusion, human urine can be used as fertilizer alone or combined with wood ash and poultry droppings and this can produce similar or even more vegetable biomass than can be achieved with no fertilization, manure fertilization or NPK+PD.

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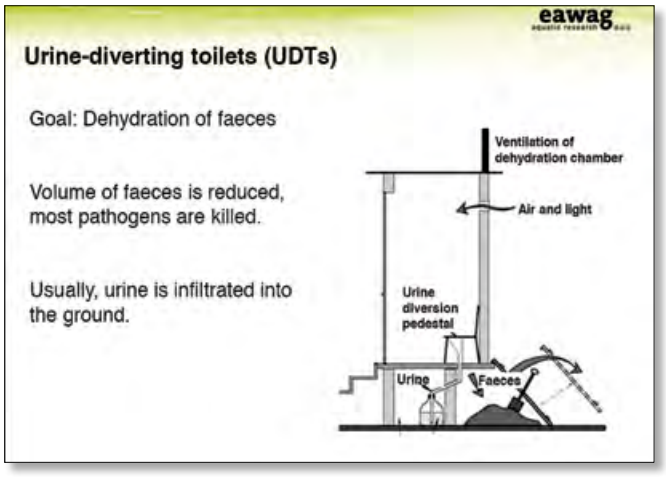
VUNA: nutrient harvesting from urine

Bastian Etter*, Teddy Gounden**, Kai M Udert*

This presentation highlighted the new VUNA project, funded by the Bill and Melinda Gates Foundation, which aims tomakeuse of the high nutrient content of urine to promote sanitation. By giving the nutrients in urine a value, the project team envisages improved toilet usage and hygiene. Furthermore, eutrophication and resulting environmental damage can be avoided, if urine is prevented from reaching water bodies. The project is a collaboration between the Swiss Federal Institute of Aquatic Science and Technology (Eawag), eThekwini Water and Sanitation (EWS), the University of KwaZulu-Natal (UKZN) and the Swiss Federal Institute of Science and Technology Zurich (ETHZ). The research pursues three major objectives:

- *Develop urine treatment technology:* Pilot-scale reactors have been developed in Switzerland and South Africa. A struvite precipitation reactor achieves approximately 95 % of phosphorus removal from urine. However, only a small part of nitrogen (5 %) and none of the potassium or sulfate contained in urine are recovered. The project not only aims at developing new technologies, but also at optimising and operating the reactors in the field in order to minimise the required costs and maintenance.
- *Optimise a network of tanks and reactors:* In the VUNA project, field trials are combined with computer simulations to develop an optimised urine collection scheme.
- *Define the socio-economic boundaries:* The investigations on urine collection are complemented with economic studies that compare varying collection patterns. Simultaneously, social acceptance of urine collection and reuse is studied to customise a public awareness campaign, which aims at improving toilet usage.



Contact details: *Bastian Etter*, Teddy Gounden**, Kai M Udert*. *Eawag: Swiss Federal Institute of Aquatic Science and Technology, Department of Process Engineering, PO Box 611, 8600 Dübendorf, Switzerland. Tel: +41 58 765 53 60; Fax: +41 58 765 53 89. **eThekwini Water & Sanitation, Education and Customer Care, PO Box 1038, Durban 4000, South Africa*

Individual perceptions & the potential of urine in agriculture in eThekwini, South Africa

Natalie Benoit

This paper explored the perceptions and knowledge of key stakeholders and the farmers with whom they are involved, about urine and its use in agriculture. Urine could be used as a fertilizer as it contains nitrogen and phosphorus. Furthermore, with urine as a fertilizer, it would now be free, accessible to all and decrease our need to mine phosphates. The research undertaken seeks to understand whether this practice would be socially acceptable in order to contribute to the debate on the potential of food security. Climate change, environmental degradation and unsustainable consumption of resources are increasingly putting a strain on the Earth's natural wealth. More sustainable behaviour such as using UDDT (urine diversion dry toilets) can help alleviate the strain on water resources. To investigate attitudes towards urine, interviews were conducted with farmers who consult with the UmBumbulu Agri-Hub and at the Newlands Mashu Permaculture Learning Centre (NMPLC). These interviews were done in order to find out their views on urine and the possibility for integrating ecological sanitation, more specifically urine reuse, in their programmes. Preliminary results illustrated that individual perceptions remain a barrier to usage; a lack of knowledge about its potential for fertilizing capabilities was also evident. In Zulu culture urine seems to be utilised in various ways, though respondents have not necessarily experienced those uses first hand. There seems to be a negative perception of urine amongst most respondents, although many farmers expressed curiosity towards the use of urine in agriculture.

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Incentivising sanitation through urine collection

E Tilley* and I Günther*

This presentation covered a 4-year interdisciplinary field-research project that aims to identify and strengthen the drivers for sanitation. In the hope of achieving 100% sanitation coverage, and surpassing the MDG targets, the project team is interested to know if urine-derived fertilizer production can be one such driver. UDDTs are waterless, above-ground toilets that separate urine from faeces. The faeces dry in one of two chambers and are reduced to an ash-like powder, while the urine is infiltrated directly into the soil. Although the toilets are not universally accepted (some families abandon or convert them to flush toilets) the Municipality of eThekwini, in South Africa, has constructed tens of thousands of UDDTs to date. Urine is rich in nitrogen, phosphorus and potassium, expensive nutrients that should not be wasted. Indeed, the possibility to recover huge quantities of nutrients from thousands of familiesis immense. The goal of this research is to determine the conditions under which urine collection, transportation and processing are attractive to both the municipality and the UD toilet user.In order to understand how much the UD toilets are used, and to begin to quantify the nutrient potential, urine production information was measured at more than 600 households. Community-scale incentivised urine collection schemes are in the process of being developed. Although the toilet is used for both urination and defecation, we consider urine to be a good estimator of toilet use, and expect to see an increase among those families who participate in the incentive scheme. The goal of EWS is to increase demand for sanitation to become 100% non-open defecation and remove the stigma that dry sanitation is for poor people.

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Management of faecal sludge from a mobile communal sanitation facility – a case study of the MobiSan

C Muanda, R Tshibangu and A Lagardien

The MobiSan® facility is a urine diversion toilet designed to contain separately urine and faeces. Faeces collected in the collection vault are drying by the wind effect and addition of saw dust. After a period of 6 to 9 months, dried faeces contained in the vault is assumed to be sanitised, thus safely handled and reused. It consists of a 20 feet ship container equipped with 13 toilets and 13 urinals as well as hand washing facilities. Sanitation technologies are designed to contain, treat or dispose human excreta in such a way that it does not impact on the human health or the environment. Substantial volume of excreta (including urine and faeces) are deposited in the sanitation system daily; and should be managed accordingly in order to prevent health risks and environmental pollution. Against this background, the aim of this study was to investigate the management of human excreta produced by the MobiSan facility before, during and after withdrawal from the containment vaults. This was achieved through the monitoring of the MobiSan facility for a period of 6 months focusing on the daily operation, turning of faeces in the vault and monitoring of the drying and sanitisation process. Results obtained suggest that the management of the faecal sludge prior and during the sanitisation process was found to be in line with the management practices of the technology while that of the final faecal sludge extracted from the MobiSan was found to be inadequate and not complying with established practices.

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Tuesday 30 October 2012 / Session B5: Breakaway 1

Experiments on struvite precipitation, application and economic analysis in Arba Minch, Ethiopia

Teshale Dalecha*, Eshetu Assefa*, Kristina Krasteva**, Günter Langergraber***

This presentation included a discussion of the first results from the CLARA struvite experiments. Source separated urine from UDDTs (Urine-Diversion Dry Toilets) is a potential source of nutrients for use as a substituent of commercial fertilizer. However, collection, storage and transportation of urine is problematic in Arba Minch. To address this problem and close the loop between sanitation products and agriculture, struvite precipitation is proposed. EAWAG's experiences in Nepal revealed that urine hygenization leads to considerable nutrient loss. The aim of the experiments in Arba Minch is to test EAWAG's experiences under Ethiopian conditions. Running the field experiment is essential for Arba Minch because of the availability of UDDTs in the town. It is planned to check the production potential and economic feasibility of struvite and its application in four different ways. The workplan for the experiments is described below:

- Urine quality analysis [April 2012],
- Struvite precipitation [April – early July 2012],
- Application on crop (maize) with best experimental protocols and adaptable combinations in number of trials [late July – early Oct 2012],
- Economic analysis [October 2012]

The work is carried out within the project CLARA (Capacity-Linked water supply and sanitation improvement for Africa's peri-urban and Rural Areas; Contract # 265676; duration: 1.3.2011 – 28.2.2014), a Collaborative Project funded within the EU 7th Framework Programme, Theme "Environment (including Climate Change)".

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Nutrient recovery from urine: operation and optimisation of reactors in eThekwini

M Grau*, B Etterb, A Hug**, M Wächter**, KM Udert**, CJ Brouckaert*, CA Buckley*

Since October 2010, the Swiss Federal Institute of Aquatic Science and Technology (Eawag), eThekwini Water and Sanitation (EWS), the University of KwaZulu-Natal and the Swiss Federal Institute of Technology Zurich (ETHZ) have worked together in the VUNA (Valorisation of Urine Nutrients in Africa) project to develop a sustainable urine collection system and adequate urine treatment processes (www.vuna.ch). 75000 urine-diverting dry toilets (UDDTs) have been installed in the rural and peri-urban areas of eThekwini to address the sanitation "backlog". UDDTs allow the separation of urine from the faeces stream by a divider inside the pedestal. The source-separated urine is a source for fertilizer production, as it contains the majority of nutrients found in wastewater streams. In a first step, a precipitation reactor was built to recover phosphorus from urine. With the first reactor set-up, a recovery of more than 91% of total phosphorus was achieved. The reactor operation will be automated and a test plant installed in the field at the Agricultural Hub in Newlands-Mashu, Durban, to run further tests and develop a user-friendly and robust process. It is intended that another reactor be setup that will be used to recover all nutrients found in urine (e.g. nitrogen, phosphorus, and potassium).

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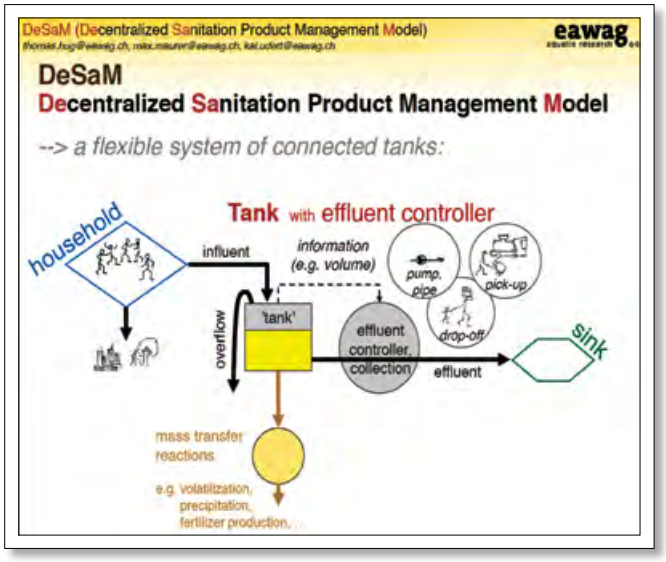
Model-based performance evaluation of the collection of source-separated urine

Thomas Hug*, Max Maurer*, Kai M Udert*

Urine-diverting dry toilets provide not only hygienic advantages but also offer the option to safely recover valuable nutrients that are highly concentrated in urine. A crucial factor thereby is the effective and cost-efficient collection of urine from a large number of distributed toilets. To design and optimise such collection and treatment networks, it is necessary to understand quantitatively the overall performance and cost of different technological and managerial options. The goal is to answer the following questions: How much urine can be made available for a treatment facility at a given location? How reliably can this amount be delivered? How can it be delivered most economically? What happens if the urine production in the catchment increases? A mathematical model will allow for the assessment of various technical aspects before a scheme is implemented. With this in mind a modular model was developed that can be applied to various combinations of geographical settings, technologies and business approaches. It takes into consideration the collection system from the households to the treatment as a hierarchically arranged series of tanks with variable volumes, and the possibility to overflow.

The mode is programmed in the freely available open-source software R and can be accessed by text or Excel files. The model was applied to the collection of source-separated urine from the outskirts of Durban, South Africa, but it can easily be adapted to assess similar questions in the context of faecal sludge management.



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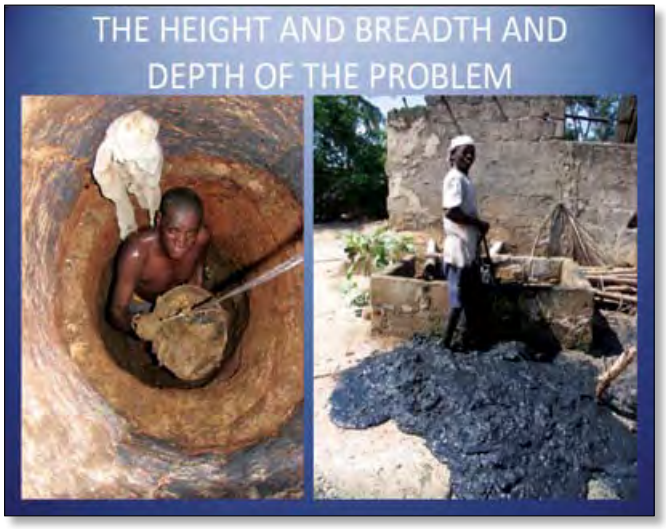
Tuesday 30 October 2012 / Session B6: Breakaway 1

Pit emptying and public health

Bobbie Louton*, Colleen Archer**, Nicola Rodda**

The provision of improved sanitation is often viewed as the key to improved health because of the assumption that contact with faeces is reduced. In the case of on-site sanitation, however, an integral part of the cycle of sanitation provision is the emptying of pits. If, during emptying, sanitation workers contaminate the household environment, improvements in health may be affected negatively. Pit emptiers risk contracting diseases caused by pathogens found in sludge. Diarrhoeal diseases are responsible for a significant share of the burden of disease and of mortalities among children under the age of five. Intestinal parasites are common in many communities, with infection rates particularly high among children, and can compromise nutrition and development. Infections are preventable if the faecal-oral route of transmission is broken. Exposure of workers and householders to the pathogens found in sludge can be reduced by examining where current practice may result in unnecessary contact with sludge and improving this practice. While national government may demonstrate an understanding of the hazardous nature of sludge, on the level of management, the handling of sludge may be viewed as a public works function which can be appropriately handled by unskilled labour. Thus, proper training and stringent protocols for dealing with a hazardous material may not be in place. A careful examination of practices can identify those which carry unnecessary risk and allow for the development of effective interventions.



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Using *Senecio LIyratipartitus* extracts as hand disinfectants after anal ablution

A Maradufu, J Obey, BC Sang, JE Khanga'ti

This presentation discussed the disinfection of hands used for anal ablution, with extracts of the *Senecio lyratipartitus* plant, also known as *Senecio lyratus*. In homes which practice anal ablution after defecation (mostly Muslim communities and some Christian homes) water is kept in pans, pots and buckets and placed in pit latrine facilities. This water may become contaminated with enteropathogenic diarrhoea causing pathogens. Ablution water samples from latrines of households practicing anal ablution in two cities, Kisumu in Kenya and Musoma in Tanzania, both located on the eastern shores of Lake Victoria in East Africa, were found to carry *Escherichia coli, Salmonella sp.* and *Klebsiella sp.* In the homes visited, there were no facilities for hand washing with clean water and soap after defecation and anal ablution. This practice is definitely responsible for contaminating drinking water, food and utensils. An initial Kirby Bauer disk method performed with the extract to show activity using the methanol extract demonstrated zones of inhibition of 15mm for E. coli, 14mm for Salmonella sp., 14mm for *Enterobacter* and 13 mm for *Klebsiella*. n-Hexane, ethyl acetate and chloroform extracts of dry leaves of *S. lyratus* were able to inhibit growth of *E. coli,Salmonella sp., Klebsiella sp* and *Enterobacter aerogenes*. The minimum inhibitory concentrations (MIC) obtained for the methanol and ethyl acetate extract were 31.5mg/mL for *E. coli*, 3.9mg/mL for *S. typhimurium*, 31.25mg/mL for *Klebsiella sp.* and 31.25mg/mL for *E. aerogenes*. *S.lyratus* grows widely in most parts of East Africa, and is currently not exploited for any commercial use. Since *E. coli* is the indicator organism for water quality, and *S.lyratus* extracts are showing activity against it, the plant has potential for development as a hand sanitiser. Suitable formulation incorporating *S.lyratus* extracts as a hand sanitiser in appropriate packaging are being developed.

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Sanitation safety plans for safe management and valorisation of faecal sludge

G Cissé*, K Medlicott**, TA Stenström**, M Winkler*, L Strande***, P Drechsel****

Recovering water, nutrients and energy from liquid and solid wastes can be a crucial part of sustainable sanitation management. However, faecal sludge management, including reuse, has to consider a range of important public health and environmental concerns. The WHO suggests developing the concept of Sanitation Safety Plans (SSP) to operationalise the Guidelines for the Safe Use of Wastewater, Excreta and Greywater in Agriculture and Aquaculture (WHO 2006). In many developing countries, inappropriate management is severely affecting the overall sanitation system, particularly the safe disposal of solid wastes, faecal sludge and wastewater. Despite significant investments in improved sanitation and sewer systems, on-site sanitation systems such as latrines and septic tanks are still the most common systems in urban areas of low-income countries. A new 3-year project, "Resource Recovery and Reuse" (RRR), involving two international organisations (WHO& IWMI), two advanced research institutes (SANDEC-EAWAG&Swiss TPH) and an international capacity building centre for water management services (CEWAS), has implemented two lines of activities: (i) Analysing the viability of existing RRR business cases and the feasibility of replicating their business models in four different cities, and (ii) Developing Sanitation Safety Plans to support safe RRR in general, with field-testing in the same four cities. Several of the business models based on the valorisation of faecal sludge will be tested for their replication potential, scalability and robustness. This presentation focused on the Sanitation Safety Plan's manual development and its six distinct tasks.

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Resource recovery from faecal sludge – an elemental approach

Jeremy Rushlow[1], Edward Antwi[2], Awarikabey Emmanuel[2], Ato Fanyin Martin[2], Wilson Tamaku[2], Johannes Ami[2], Timothy Wade[3], Bob Armantrout[1], Moses Mensah[2], Ashley Murray[3], Kartik Chandran[1],*

This presentation highlighted a BMGF project in Kumasi, Ghana, where researchers from the Columbia University, in partnership with Waste Enterprisers and KNUST, are engaged in the conversion of faecal sludge organics to liquid biofuels such as biodiesel and, potentially, methanol. A significant part of the world's population lacks access to sanitation and the principal limitation of current sanitation approaches is that they follow an oxidative approach. Essentially, if human faecal sludge is reduced to its elemental composition, then the principal components are carbon (mainly organic, in the oxidation state 0), nitrogen (mixture of organic and inorganic, in the oxidation state -3) and phosphorous (mainly in oxidation state +5). Thus far, the wastewater treatment and sanitation sectors focus on oxidising the carbon and nitrogen to oxidation states of +4 and 0, respectively. This approach results in high energy, resource and cost input. The basis for both technologies (biodiesel and methanol) is biological anaerobic fermentation, which relies upon the *reduction* of the organic carbon in faecal sludge. The products of fermentation are chemically converted to biodiesel and biologically converted to methanol. After purification, the methanol can itself be used as a chemical substrate for biodiesel production, thereby further reducing the operating costs. This project is being conducted at pilot-scale at a design capacity of 10m^3 faecal sludge per day and an overall bioreactor volume of 120m^3.

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Enhanced anaerobic digestion as a sanitation and energy recovery technology

T Garoma, C Williams and D Nguyen

This presentation discussed a novel enhancement to an existing technology, which involves the enhancement and adaption of an anaerobic digestion (AD) system that will treat waste and generate a reliable supply of biogas from the codigestion of algal biomass and waste, providing an incentive for a community to adopt and self-sustain the enhanced AD system. This research seeks to develop an enhanced AD system that uses algae as a supplementary feedstock to treat human waste reliably and inexpensively, while generating biogas as a fuel for energy and biosolids for use as fertilizer. To validate the concept, wastewater sludge was used as a representative "human waste" and two species of algae were used, *Chlorella sp.* and *Scenedesmus sp.* The study conducted a number of bench-scale experiments, and co-digested sludge and algae in varying proportions for one- and two-month detention times at 35°C. The results show that the enhanced AD system is an effective waste treatment technology, having produced higher energy yields and digested waste low in faecal bacteria and high in nutrients. This technology collects, contains, and treats waste in the same reactor, making it suitable for rural and urban communities with no sewer connections. Additionally, it is versatile and can be modified to fit for communities of all income levels. The proposed technology has the potential to be developed into a reliable, inexpensive, and sustainable waste treatment system.

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Effective sewage sanitation with low CO_2 Footprint

Joan Colón Jordà, Aaron A Forbis-Stokes, David E Schaad, and Marc A Deshusses

This presentation discussed the development of a novel self-contained and energy-neutral sanitation technology that relies on anaerobic digestion of human wastes to generate biogas, which is then used to heat-sterilise the treated effluent. An effective heat exchanger increases the efficacy of the heat sterilisation. The process being developed is simple and low-cost, and eliminates methane emissions (a potent greenhouse gas). It could be suitable as a replacement for the pit latrine, and, depending on the organic loading, could provide extra biogas for cooking. The current research has two main areas of focus: a) The anaerobic digester (initially lab-scale) and b) the heat sterilisation system (full-scale or near full-scale). A floating dome lab-scale digester with a working volume of 17 litres was built and used for the anaerobic digestion of simulant faeces and urine. The bioreactor is currently working with an organic loading rate of 1.8 kg_{COD}/($m^3_{reactor}$ day) with a maximum biogas production of 15 L/d and a total COD removal efficiency close to 85%. The biogas produced contains about 60% methane. The lab-scale digester is roughly 1:30 scale, and thus a full-scale digester for an extended family of 10 would need to have a working volume of about 0.6 m^3. It would produce about 400 to 450 L of biogas per day. Biogas (or a mimic of methane and CO_2 in some lab experiments) is burned in a custom-built heater designed with readily available parts that brings the effluent liquid above 70°C. Experiments under realistic conditions showed 6 to 10 log reductions of *E. coli*. We are currently working towards the design of full-scale prototypes for a field demonstration.

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Self-mixing biogas generator

Tim Canter and Jianmin Wang

This presentation discussed the development of a self-mixing, high-rate biogas generator to enhance waste-to-energy conversion, by Frontier Environmental Technology, that reduces reactor size and cost. The key feature of this novel biogas generator is a hydraulic structure that collects and coalesces dispersed small biogas bubbles within the reactor, and then releases them instantly as a large bubble in the central pipe, to mix the entire reactor and also prevent sludge build-up at the bottom. This new reactor will provide both the operational simplicity of conventional, non-mixed reactors and the efficiency of high-rate reactors. Biogas generators can be used to digest residential sewage and livestock manure to: (a) reduce pathogens and related disease outbreaks, (b) produce a clean fuel for cooking and heating, (c) reduce pollutant loading from households, and (d) produce stabilised sludge for land application as a fertilizer. However, the conventional biogas generator is usually very large, which requires significant capital for construction. Based on current design guidelines, the tank volume needed per person is 1.2 to 1.5 m^3. The key factor that differentiates a high-rate digester from a conventional digester is the intensity of mixing. Mixing in conventional biogas generators (e.g., digesters) is provided by dispersed biogas bubbles produced during the digestion process. This mixing is very mild and not sufficient to provide effective contact. In order to improve digester performance, forced mixing is needed by either recycling biogas or using mechanical mixers. However, this type of operation typically requires external energy and trained technicians for additional maintenance, neither of which is generally available for small-scale and/or rural applications in developing countries.

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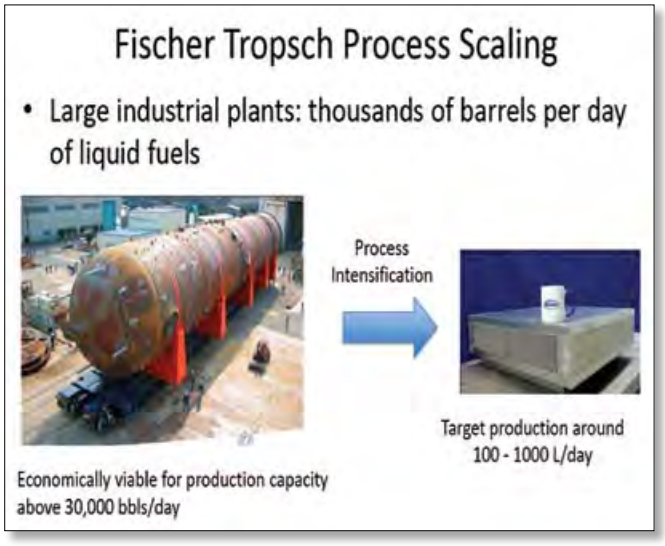
Conversion of faecal sludge to liquid fuels. Why and how could it work for small-scale applications?

Leonardo De Silva Muñoz*, Gustavo Montalvo Javé*, Lorenzo Martínez Martínez-de-la-Escalera*

This presentation provided an overview of the progress made in a theoretical study for the small-scale production of diesel fuel from faecal sludge and municipal solid waste mixtures through the use of gasification and the Fischer-Tropsch (FT) technology. A low cost simplified version of a gasification + FT plant was presented along with an energy balance that shows the viability of the process. Waste to energy conversion is a promising route for reducing the fossil fuel dependency of the world. Fermentation, chemical processing, pyrolysis and gasification have been the main processes used for transforming biomass and other "burnable" wastes into useful fuels like ethanol, methanol, biogas, bio-diesel, bio-oil, bio-hydrogen etc. Most works on the subject are focused on power generation or on the production of alternative fuels, while few consider the option of producing gasoline or diesel. Gasoline and diesel can be produced from bio-waste through gasification, a process that produces a mixture of hydrogen and carbon monoxide known as syngas, and a method known as the FT process. FT has been implemented by some companies (Sasol, PetroSA, Shell) for the production of high value hydrocarbons from coal and natural gas. These plants are normally large, with production capacities of thousands of barrels per day. At a smaller, local scale it may be economically attractive to process faecal sludge for the production of liquid fuels.



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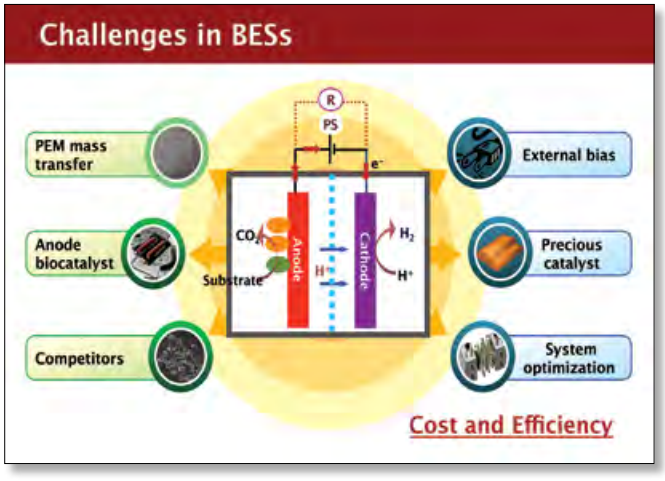
Tuesday 30 October 2012 / Session C5: Breakaway 2

Highly efficient microbe-mediated energy harvesting from wastewater through nanomaterial decorated three-dimensional multi-length scale porous matrix electrode

Arum Han*, Celal Erbay*, Yeontack Ryu**, Choongho Yu**, Mi-Jin Choi*, Paul de Figueiredo***

The purpose of this project is to develop a self-sustainable Microbial Fuel Cell (MFC) -Microbial Electrolysis Cell (MEC) coupled hybrid system that directly generates electricity from wastewater using locally available microbes, which is then utilised by the MEC part of the system to generate high-purity biogas as a clean combustible fuel source. MFCs are "green energy" devices utilising microbial metabolism to directly generate electricity from organic substrates, and have generated excitement in environmental and bio-energy communities due to their potential for coupling wastewater treatment with energy generation. However MFC technology has not yet been put to practical use because of its low power density compared with other fuel cell technologies. Biogas such as biomethane and biohydrogen generated from organic waste are green energy sources of great interest. Recent developments in bioelectrochemical systems such as MECs that allow electrochemically active microbe-mediated methane and hydrogen generation have the potential for economic and high purity biogas generation. A three-dimensional multi-length scale porous matrix electrode has been developed, decorated with carbon nanotubes to significantly increase MFC performance to rapidly treat wastewater and generate sufficient energy for practical use.



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Decentralised organic and nitrogen removal from domestic waste in rural Ghana with a microbial fuel cell

Cynthia J Castro[1], Joseph E Goodwill[1], Brad Rogers[2], Mark Henderson[2], Caitlyn, S Butler[1]

This presentation provided an insight into a study involving the development of a cost-efficient pilot scale MFC that would remove organics and nitrogen compounds directly from human waste and to deploy the pilot design in rural Ghana. An MFC was incorporated into the design of a simple composting latrine that is commonly found in rural regions of Africa allowing for utilisation of local materials, labour and operation. MFCs with low biomass growth and electricity yield are a promising energy efficient technology for waste treatment. Although many bench-scale MFC systems have sustained power production, few studies have examined these systems at a pilot scale. In the proposed system, solid wastes are filtered into a composting chamber and the remaining liquid stream is passed to an MFC. The MFC design consisted of three compartments: the anode chamber ($28L_{Liquid}$), where COD was oxidised by anode biofilm, an intermediate nitrification chamber ($45L_{Liquid}$) supporting aerobic microorganisms, and the cathode chamber ($28L_{Liquid}$), where nitrate was reduced to inert nitrogen gas by a cathode biofilm. One of the primary advantages of the MFC latrine system design is that it can be retrofitted to existing latrines with minimal disruption to existing sanitation systems. Prior to the system construction in Ghana in May 2012, an analogous, lab-based pilot MFC was constructed. The MFC anode biofilm oxidised 74 mg COD/l-d, achieving over 98% percent removal. The total nitrogen removal rate was 34 mg N/l-d or 68% of nitrogen removal. Power production was low, 2.5 mW/m^3. Significant factors identified as limiting power production in this system were ohmic losses due to the electrode material and conductivity of the waste stream. Though power production was low, the system was able to power a LED light, a useful resource in a rural, developing area where electricity is not reliable.

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Energy production and sanitation improvement using microbial fuel cells

I Ieropoulos*, J Greenman**, D Lewis* O Knoop***

This presentation reported on the preliminary findings from the study of a collection of small scale MFCs, working both as individual units in cascade or collectively as an interconnected stack utilising artificial urine. This is part of a larger study that is investigating the potential of the MFC technology to generate energy whilst treating urine waste, to produce clean water and to render harmless any pathogens that might be present. According to the Water, Sanitation and Hygiene Programme of the Bill & Melinda Gates Foundation, 1.5 million children die as a result of water-borne diseases and 2.5 billion people use unsafe toilet facilities or defecate in the open. The potential for MFC technology to utilise wet organic waste products (including human urine) has been previously reported on. Artificial urine was prepared from pure chemical components at concentrations typically found in real urine. MFCs were constructed from Nanocure® resin polymer using rapid prototype technology. MFCs showed stable performances following the maturing period and produced, under polarisation experiments, peak power output levels of the order of 39.6μW (absolute value), which corresponds to 39.6W/m^3 (normalised value). Data from continuous flow experiments showed higher power production, increasing with the concentration of the C/E source within artificial urine. The work has demonstrated that artificial urine of varying composition can be successfully utilised for the production of energy, whilst being treated inside MFCs.

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Ethics and faecal sludge management in Africa

Ujah Oliver Chinedu*, Mathew Ocholi**, Kabou Kambou**, Ali Dissa**, Katie Spooner**, Rakia Kere**, Joseph Makaya**, Ada-Oko Williams** and Idrissa Doucoure**

This presentation provided an insight into the study that highlights the values/principles that govern the actions and decisions of individuals or groups with regard to sanitation choices and/or services. The logical linkages between sanitation and ethics are critical for achieving dignifying, effective, efficient, scalable and sustainable sanitation services delivery. This linkage, when perfectly established, has the potential to address the challenges of sustainability and scalability of sanitation models being promoted in the continent. WASH supply to poor rural and urban populations has remained a continual problem for Africa and other developing nations. This is despite global consensus that the right to safe WASH is derived from the right to an adequate standard of living, and is inextricably related to the right to the highest attainable standard of physical and mental health, as well as the right to life and human dignity. While it is universally accepted that it makes economic, social, political and environmental sense to promote adequate sanitation access, it is also important to examine whether the sanitation services being promoted in Africa are adequately dignifying, especially in terms of access quality as against universal access. The first important aspect of faecal sludge management is faecal sludge collection, and a number of low-cost capture technologies, in the name of improved access, are being promoted in the continent. Feedback from 30 purposively selected respondents was examined to determine whether any form of rights and choices exist in the context of inaccessibility and/or poor accessibility to sanitation services.

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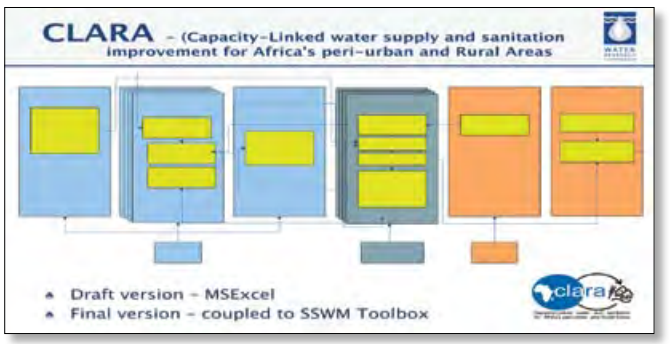
The Clara Project – capacity-linked water supply and sanitation improvement for Africa's peri-urban and rural areas

Guenter Langergraber[1],*, Mirko Haenel[2], Elke Müllegger[3], Elisabeth Freiberger[3], Rafael Casielles[4], Sami Sayadi[5], Benedict M Mutua[6], Valerie Naidoo[7]**, Ali Dissa[8], Mokhtar Jaait[9], Teshale Dalecha[10]

The overall objective of the Clara Project is to strengthen the local capacity in the water supply and sanitation sector which is needed to adopt, implement and operate integrated resource-oriented water supply and sanitation solutions. There are a large number of small communities and towns in Africa that suffer from severe problems with water supply and sanitation. Small communities in rural areas and peri-urban areas of small towns have comparable settlement structures in which reuse of water and use of sanitation products can be utilised. However, there is only limited local capacity to adopt, implement and operate integrated water supply and sanitation. From a technological perspective, existing low cost technologies for decentralised water supply and sanitation systems shall be assessed and adapted for African conditions with the focus on reducing risks in use and reuse of water and sanitation products, and providing demand oriented water quality. Based on these technological improvements and the experiences from the FP6 projects ROSA and NETSSAF, a simplified planning tool for integrated water supply and sanitation systems for small communities and peri-urban areas shall be developed. This planning tool would incorporate the key factors for success (operation and maintenance issues and reuse potential) tailored to available local capacities. This simplified integrated CLARA planning tool shall then be tested and evaluated in various African regions to incorporate different economic, cultural and social boundary conditions.



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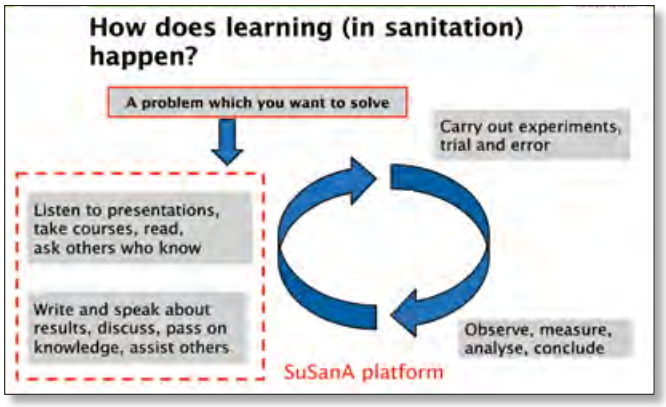
Accelerating learning in sustainable sanitation

E von Muench*, T Surridge*, D Spuhler** and A Rosemarin***

This presentation showcased the Sustainable Sanitation Alliance's (SuSanA's) approach, and demonstrates its working groups, publications and the discussion forum for inter-sectoral learning, which foster long-term access to sustainable sanitation for all members of society. SuSanA is an active network currently comprising 190 partner organisations worldwide who share a common vision on sustainable sanitation. Partner organisations include local and international NGOs, research/education institutions, UN organisations, donors, private sector organisations and others. SuSanA offers a coordination platform, sounding board, and catalyst for policy dialogue on sustainable sanitation. The presentation demonstrates how SuSanA uses internet-based communication tools, namely the open SuSanA discussion forum at www.forum.susana.org, facebook, flickr, youtube and its website www.susana.org to assist learning within the sector and to reach out to other related sectors, such as urban planning, public health, schools, business, agriculture, and emergency response. The SuSanA discussion forum was launched in mid 2011 and now has 1500 registered members. It is already an important knowledge exchange tool. All postings are accessible with general internet search engines and this allows "outsiders" to find and follow in-depth discussions that experts and practitioners are having on a range of topics. The forum stresses a systems approach to sanitation, as well as "open-source" learning and sharing, with the philosophy that progress in the sector is most efficient if we dare to openly discuss failures and success stories and if the atmosphere is supportive and not anonymous.



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Wednesday 31 October 2012 / Session A7: Main Hall

Thermophilic co-composting of human wastes from urine diversion toilets in Haiti

N Preneta, S Kramer**, B Magloire*** and JM Noel****

In this presentation, Sustainable Organic Integrated Livelihoods (SOIL) presented their research findings regarding the safety and agricultural potential of compost produced from human waste using thermophilic composting. The discussion focuses on both the successes and failures of the system, highlighting proven concepts and potential improvements based on the research. It is hoped that this information will be valuable for other conference attendees looking for ways to safely valorize human excreta. SOIL is an organisation that has been working on ecological sanitation in Haiti since 2006. Haiti has the lowest sanitation coverage in the western hemisphere, and prior to 2010 Haiti had no centralised waste treatment sites. In 2009 SOIL developed Haiti's first waste treatment site to treat human waste using thermophilic co-composting. SOIL has since expanded to two large treatment sites in Cap Haitien and the capital of Port au Prince, which are now treating over 5000 gallons of human waste per week and serve approximately 15 000 people. The compost produced from the waste is currently being sold to local and international organisations for use in reforestation and agriculture projects. This presentation will focus on the collection and treatment process currently being used by SOIL in Haiti, with a specific focus on the co-composting methodology and research. SOIL's composting process uses bagas (a sugarcane by-product) and human waste to create a composting environment which reaches temperatures of over 70°C within several days of dumping, and maintains these temperatures for a period of more than 1 month, rendering the resulting compost pathogen free.

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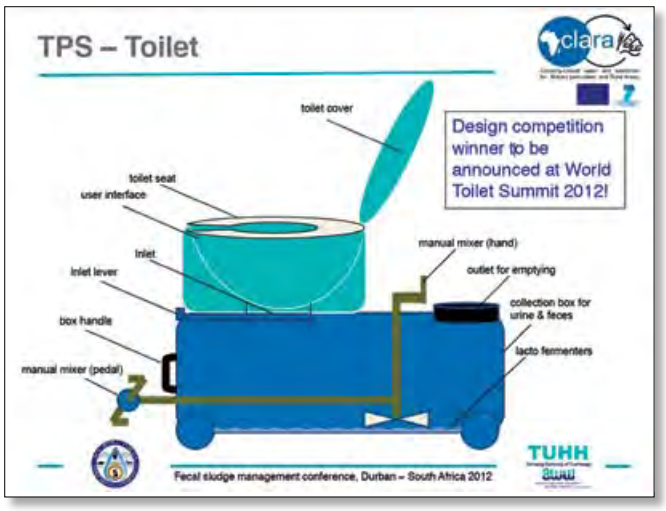
Experiments on co-composting of human excreta with bio-char in Arba Minch, Ethiopia

M Bulbo[1], A Yemaneh[1], T Dalecha[2], T Amlaku[3], K Krasteva[4], G Langergraber[5], R Otterpohl[1]

This presentation focused on work that has been carried out within the project CLARA (Capacity-Linked water supply and sanitation improvement for Africa's peri-urban and Rural Areas) a Collaborative Project funded within the EU 7th Framework Programme, with the Theme "Environment (including Climate Change)". The potential of human urine, faeces, and other bio-waste as sources of plant nutrients and soil organic matter is not yet fully utilised. Lack of appropriate technology for processing the waste streams is one of the major reasons for the limited success so far. These experiments are aimed at improving human waste processing in Arba Minch, Ethiopia. The impact of biochar in co-composting of urine, faeces, and bio-waste is assessed. The extent of conservation and concentration of plant nutrients through the process is investigated. An assessment of health risks associated with operation and product usage is part of this study. Results have shown significant reduction in the volume to fertilising value ratio of the end product. The addition of biochar is observed to improve operation in co-composting. This study shows that co-composting of urine and faeces with other bio-waste and biochar generates nutrient and humus rich soil which can be used as an amendment agent especially for application on sandy soils. The CLARA team is grateful for the support. Additionally, the PhD work of Mammo Bulbo is supported by the Government of Ethiopia Engineering Capacity Building Program (ECBP) and German Academic Exchange Services (DAAD). Both are duly acknowledged.



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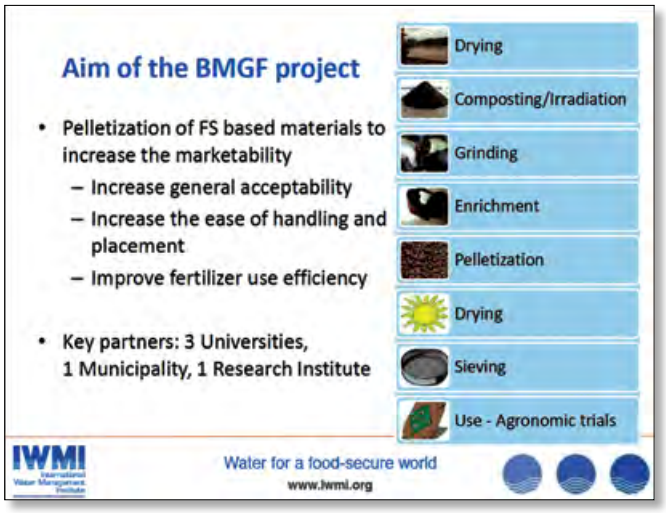
Fortified excreta pellets for agriculture

J Nikiema, O Cofie , R Impraim, P Drechsel

This presentation provided an overview of studies conducted on the pelletisation process of faecal sludge-based fertilizers. The equipment used for the process was fabricated in Ghana using local expertise. Each fertilizer product was individually used for the production of cylindrical pellets (particle diameter: 7.5 to 7.7 mm, length: usually 10-20 mm). From the current study, the binding material type (cassava starch, either pregelatinized or pre-treated by gamma irradiation, or kaolin clay) and concentration (0 to 10% in mass) as well as moisture content (20-35%) appeared to be the most critical factors during the pellet production. It was noticed that the higher the binding material concentration, the higher the strength of the pellets, but the variation of pellet's stability following two hours of shaking at 300 motions per minute is usually below 5%. It was concluded that a starch concentration of 1-3% could be enough during the pelletisation process, starch being preferred to clay. This is significantly below the 15% of pregelatinized cornstarch, needed to produce pellets (particle diameter: 13 mm, length: 25 mm) from organic waste compost, recommended from anterior experiments in Nigeria. This study confirms that it is possible to produce excreta-based pellets in small and medium size enterprises with local machinery. Upcoming studies will include testing the pellets in a greenhouse to confirm their suitability for different soil types and crops. If successful, such application could help make faecal sludge reuse a clean and safe process for private entrepreneurs as well as farmers.



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Towards sustainable pit latrine management in south africa through the LaDePa pelletising machine

John Harrison, Dave Wilson

This presentation provided a brief overview of the LaDePa (for **La**trine **De**hydration **Pa**steurisation) technology, as well as its environmental benefits, the challenges it addresses, and provided an overview of the Supply Chain Management regulation compliant, procurement model that EWS intends employing. world is fraught with challenges, particularly in South Africa where some additional institutional challenges have arisen due to its history. eThekwini Water and Sanitation (EWS), the municipal entity responsible for providing sanitation services to Durban and its surrounds, has co-invented and piloted an inexpensive, mobile, containerised technology, called LaDePa (for **La**trine **De**hydration **Pa**steurisation) that converts stiff, pit latrine and other sludge, into a pasteurised, dry, "handle-able" product, that is beneficial for general agricultural use including root crops. The inexpensive, simple and robust mechanics employed by LaDePa, its mobility and low capital cost, not only address the major technical and institutional challenges of sludge management, but also addresses some socio-economic challenges in the communities where pit latrines are encountered, making outsourcing of the Pit Latrine Service viable. EWS intends privatising its pit emptying program anchored on the LaDePa technology.

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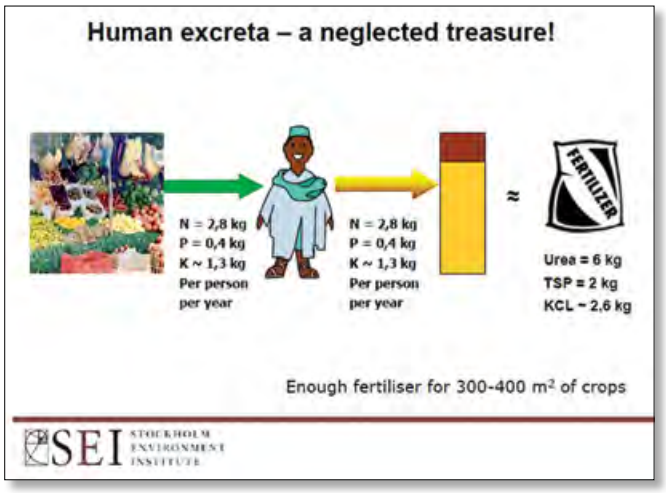
Wednesday 31 October 2012 / Session A8: Main Hall

Beneficial use of faecal sludge through deep row entrenchment

D Still*; H Salisbury**; S Lorentz**; K Foxon**

This presentation provided an insight into the suitability of deep row entrenchment of faecal sludges as a disposal option, that has been investigated by the Water Research Commission in South Africa over the past three years. Faecal sludges contain nutrients (N, P, K) which make them a potential resource and not necessarily a waste, but they also contain pathogens which makes them unsuitable for surface spreading, particularly where edible crops are to be planted. Deep row entrenchment retains the nutrient value and safely contains the pathogens until they die off. The topics of interest to the researchers have been the effect on the growth of trees planted over or close to the entrenched sludge, the fate of the pathogens and the effect on the groundwater. Buried faecal sludge acts as a slow release fertilizer and makes a marked difference to the growth rate of trees. The difference in tree volume is significant, although the relative difference between experimental trees and controls does seem to be decreasing with time. Regarding the fate of pathogens, *Ascarislumbricoides* (large roundworm) is used as a marker for parasites because its eggs are very hardy: if treatment leaves no viable Ascaris eggs it can be assumed that all other parasites have been eliminated as well. Analysis of sludge extracted at intervals indicates that no viable Ascaris will be found after a period of 30 months. Groundwater near the entrenchment sites is being monitored for a range of determinands which would indicate if the sludge has affected water quality. At one site, which is flat and sandy with deep soils, no impact has been observed, while at the second site, which is sloping with shallow soils, some increase in NO3 has been observed. This indicates that sites selected for deep row entrenchment should ideally be flattish and have deep soils. One of the topics of further research work is to determine how nutrients such as NO_3 and P are stored and migrate within the soil.



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Assessing pollution risk from buried sludge

S Lorentz* P Adadzi* D Still** and B Wickham*

This presentation compared the impact of buried pit latrine waste and sewage sludge at two distinctly different sites.These two case studies highlight the importance of a clear understanding of the flow pathways and fate mechanisms at disposal sites. The movement of nutrients and pathogens from sources of buried human excreta has been studied in many controlled experiments and *in-situ* observations. Controlled experiments have led to some understanding of the fate of nutrients and pathogens in porous media, both in the saturated and unsaturated state. Studies of *in situ* subsurface sewage sources, whether placed or from on-site sanitation, however, vary significantly in their conclusions of the distances and impact of nutrient and pathogen movement. While it is clear that distances to groundwater bodies, residence times in unsaturated zones and redox conditions influence the fate of nutrients, specific site conditions, including subsurface soils and geology as well as climate, require careful assessment of their influence on buried sewage impact. At the trenched pit latrine waste site, the unsaturated zone of the alluvial sandy material seems critical in limiting the impact, while at the sewage sludge trenched disposal site on a shale and dolerite hill slope, near surface lateral flow during the wet season, conducts significant nutrient loads downslope.

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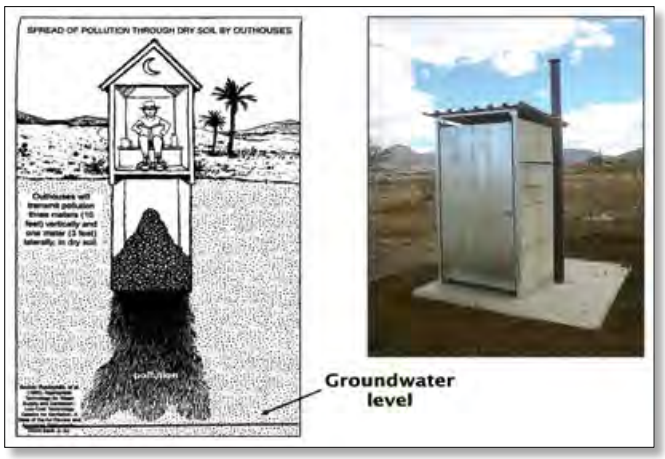
Dealing with the rural sanitation backlog in the Chris Hani District Municipality, South Africa – a case study

Viv Mostert

The Chris Hani District Municipality (CHDM) inherited thousands of VIPs from the (then) Department of Water Affairs and Forestry (DWAF). These were mostly VIPs with fixed top structures built of concrete blocks which would require CHDM to deal with the faecal sludge in full pits. Based on this experience, they took a conscious decision to adopt a different approach to all new rural sanitation facilities to be constructed. The South African national Free Basic Sanitation policy requires basic sanitation facilities to be provided to indigent households. In the CHDM the majority of residents live in hundreds of scattered, rural villages where most of the sanitation backlog occurs. Consideration was given to different ways of dealing with the provision of the basic rural sanitation facilities as well as the financing and management of the ongoing operation and maintenance of the facilities. It was recognised that, unlike urban and peri-urban situations, an additional factor to be considered in very rural areas is a logistical one since this has a major influence on the chosen approach to the problem. It was decided that the basic rural sanitation unit was to be the Ventilated Improved Pit-latrine (VIP) but with a moveable top structure. The moveable top structure was the indirect way of dealing in a cost-effective, sustainable manner with the faecal sludge of the VIPs when their pits were full. The provision of VIPs with moveable top structures to some 100 000 families was done through a 3 year supply and installation contract for R782 million with no payment being made for materials on site. Payment was only made for certified, completed units. This required the further appointment of Administrators to carry out the quality control and certification of work done.



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Direct mode-solar sludge drier

Joseph Tchangwani Magoya* and Chifundo Tenthani**

This presentation discussed a solar sludge drier that was designed, fabricated and tested at the Blantyre City Council Sewage in Zingwangwa, Blantyre, Malawi. In the peri-urban areas of Malawi, the management and utilisation of sludge from full latrines still remains a challenge to many households without sewer connections. Existing methods for managing this sludge are limited and uneconomical. Latrine sludge is not seen to have economical value in rural and peri-urban areas of Malawi. Emptying the latrines and managing the sludge is also not lucrative as the costs are high and most of the clients are low earners. The emptied sludge is never utilised. If properly utilised the sludge would have an economic value as it can be turned into manure for direct use in agriculture or for sale to commercial farmers. Preliminary results indicate that a maximum temperature of 57°C was achieved, which is within the range required to kill pathogens and enable the sludge to be converted into manure. The study concludes that a solar drier can be used to treat sludge and convert it into usable manure which is rich in nitrogen and phosphorous. This can then be used in depleted and eroded soils.

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Fuel potential of faecal sludge - calorific value results from Uganda, Ghana and Senegal

T Nakato*, L Strande**, C Niwagaba*, H Dione***, N Baawuah****, A Murray*****

This presentation highlighted research aimed at testing the viability of using FS as solid fuel – an end use that could unlock an environmentally and financially beneficial replacement for costly, disposal-oriented FS management solutions. Using faecal sludge (FS) as a fuel to provide energy for industry could help to solve both the sanitation challenge and reliance on dirty or expensive fuels. To determine the average calorific value of FS, and how it varies with source and age, samples were collected in three cities: Dakar, Senegal; Kampala, Uganda; and Kumasi, Ghana. Samples were tested for calorific value, total solids and water content. In Kampala, samples were collected from unlined, fully lined and partially lined pit latrines, septic tanks, and drying beds fed with FS from these systems. In Dakar, samples were collected from septic tanks and drying beds fed with raw FS. In Kumasi, samples were collected from public and private lined pit latrines, septic tanks, and anaerobic ponds to mainly assess the effect of biological treatment on the calorific value. The total solids of FS from unlined pit latrines was 6% of wet weight, which is higher than that in lined pit latrines at 2.7% of wet weight and septic tanks at 1% of wet weight. This is attributed to the water in the unlined pit latrine sludge draining into the soil. For industries to derive net energy from FS at 17.2 MJ/kg DS, the sludge must be dried to ≥ 27 % dry solids. Any increase in dry solids above 27% increases the energy requirement to dry the FS, but also increases the benefit to the end user. The total solids of FS from drying beds in Kampala was above 30% of wet weight after two weeks, indicating that additional energy for drying the FS can be harnessed with minimal recurring costs assuming land is available.

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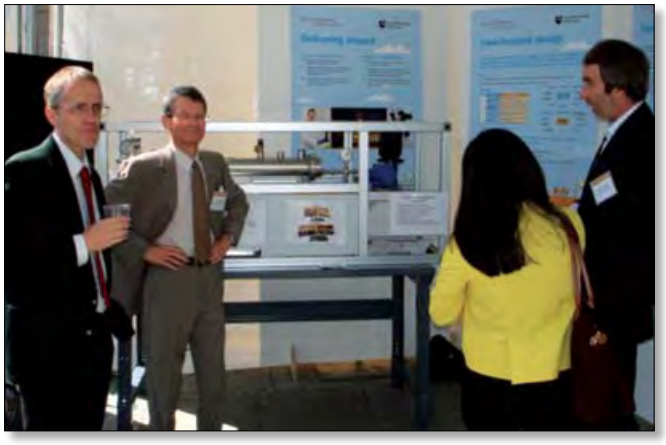
A toilet system based on hydrothermal carbonisation

E Danso-Boateng*, R Holdich*, S Martin**,
A Wheatley****, D Gyi*** and S Khan****

This presentation highlighted the development of a toilet system that converts faecal sludge to an aqueous suspension of carbonised material that is safe to handle and readily separated from the remaining liquid. The system will also extract useful salts from the liquid. In order to allow the system to be deployed in areas where no (or very crude) sanitation exists, it is designed to be self sufficient in terms of energy input and to a scale which enables up to a thousand users . The system, in conjunction with engineering contributions, is being designed to provide users with a positive and comfortable experience. The work is funded by the Bill and Melinda Gates Foundation. Hydrothermal carbonisation (HTC) has received a lot of attention recently as a way to convert biomass - including sewerage - into coal-like material. It involves heating the original material in water at high temperatures and pressures. Most HTC work involving sewerage treatment is currently aimed at replacing established treatment plants, i.e. in places with well-developed sewerage services. In contrast, our system is aimed at bringing sanitation to areas where none currently exists. The work will characterise the energetics of the HTC process for optimal total energy input, and will demonstrate how this information has been used to develop a continuous system based on a plug flow reactor. In order to minimise the amount of water required to flush material away from the toilet bowl, and to help maintain high sanitary standards, anti-fouling coatings for the system have been investigated.



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Thermal processing of solid waste to biochar in urban settings

Brian Von Herzen,* Paul Csonka,** Ken Chaney,* Randy Hall,* Eli Goldstein,** Ben Jensen,** Ani Vallabhaneni,*** Kieran Stolorz,* Graham MacWilliams,* James Choi,* Duncan MacWilliams* and Reginald Mitchell**

This presentation discussed a biochar reactor that has been developed with the support of the Gates Foundation. This technology can improve on western toilets and waste management systems without using an external water supply and without requiring external electricity. From this novel perspective, processing solid waste can be viewed as a moisture problem: how can the moisture be removed and the sludge sanitised? These solutions are particularly appropriate for a drought-stricken world, an increasingly common occurrence in the face of global warming. The biochar reactor converts solid waste into biochar for use as an agricultural fertilizer and for carbon sequestration. Incoming solid waste is dried and pyrolyzed into biochar. In this process, a syngas is generated, which is burned, supplying energy for drying and pyrolysis. The lean-burn environment also reduces odors and processes partial combustion products to CO_2. Sterile biochar is produced that is suitable for application as a fertilizer substrate in agriculture. The biochar reactor is highly insulated to reduce thermal losses to the environment. The system is designed to run at a pressure lower than atmospheric, ensuring that odours are consumed in the second-stage combustor rather than being emitted to the environment. This approach minimises odours, thus enabling it to operate in urban settings.

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Human excreta to energy and biochar in urban Kenya

Jason Aramburu* and Luke Iseman**

This presentation provided an insight into the conversion of solid faeces to biochar, thus offering a novel pathway for low-cost, sanitary waste treatment.

Waste is added to batch pyrolysis reactors, which desiccate and heat the waste to temperatures over 300°C under low-oxygen conditions.

Rather than combust into ashes, the waste is converted to an inert, carbon charcoal (biochar). Heat from the pyrolysis process is used to stabilise urine.

When added to agricultural soils, biochar has numerous beneficial properties including increasing water/nutrient retention and boosting cation exchange capacity. Biochar may also have long-term impacts as a carbon sequestration tool.

re:char, a biochar company, has developed and is currently testing a simple batch reactor to convert a mixture of human faeces and agricultural waste into biochar. These reactors are designed for deployment in urban and peri-urban areas of East Africa.

We have demonstrated 99% complete pathogen destruction via conversion to biochar, as well as 20-40% increases in maize/millet yield through the use of faecal biochar as a soil amendment.

We have also demonstrated positive growth impacts by supplementing the biochar with stabilised urine diluted to 15%.

re:char's pyrolysis reactors are targeted with an operating and capital expense of <$.05/user/day.

Low capital cost is achieved through distributed manufacturing and use of locally available building materials.

The end goal of the project is to incorporate a pyrolysis reactor directly into a freestanding toilet structure, eliminating the need for transport of faecal solids.

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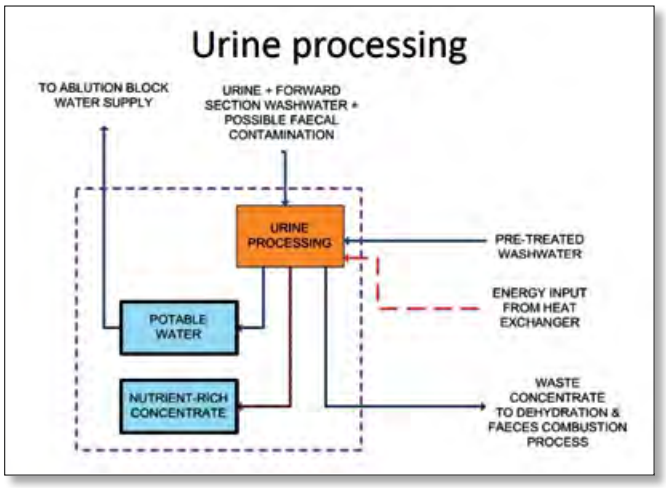
Reinvent the toilet – University of KwaZulu-Natal

C Buckley*, R Cottingham*, S Woolley* and D Horstman*

The Pollution Research Group (PRG) received a grant from the Bill and Melinda Gates Foundation (BMGF) to participate in the Reinvent the Toilet Challenge (RTTC). The Challenge end objective is to produce a new-generation self-sustaining toilet that is able to convert human waste into sterilised fertilizer, potable water, mineral salts and electrical energy for a total (capital and operating) cost of under USD 0.1 per person per day. Work has focused on four areas: (i) design of a three-way split pedestal producing mixed solids, urine and soiled washwater streams; (ii) characterisation of human excreta from individual donors and mixed excreta streams from community ablution blocks; (iii) a solids processing system, and (iv) a urine processing system. A three-stage membrane treatment process is under study for faecally-contaminated urine, consisting of microfiltration, nanofiltration and forward osmosis stages. Microfiltration will act as a screening stage to remove particulates and reduce downstream fouling. Nanofiltration is being assessed for its potential to separate the waste solute components from the screened urine (including pharmaceutical compounds and undesired inorganic salts). The forward osmosis stage will be used to recover potable water and concentrated urea as separate product streams. The primary driving force for forward osmosis can be supplied from low grade heat, with the draw solution re-generated from components found in the urine feed.



Contact details: *C Buckley*, R Cottingham*, S Woolley* and D Horstman*. * Pollution Research Group, School of Engineering, University of KwaZulu-Natal, Howard College Campus, King George V Avenue, Durban 4041; Tel: 031 260 1122; Fax: 031 260 3241*

Properties of faecal sludge

K Velkushanova*, L Zuma* and C Buckley*

The Pollution Research Group (PRG) at the University of KwaZulu-Natal, Durban, South Africa was contracted by the Bill and Melinda Gates Foundation (BMGF) to carry out a study of faecal sludge properties from different types of on-site sanitation facilities. Previous work of PRG established that there is not enough information in this field. Furthermore, the faecal sludge characteristics may vary greatly between different locations, types of facilities, geological conditions and number of users. In order to explore the variability in details, a pit emptying programme has been undertaken to obtain sludge samples from selected on-site sanitation facilities of low and high use, including: wet and dry household VIP latrines, household UD toilets, household unimproved pit latrines, community ablution block VIP latrines, and school VIP toilet blocks. The selected samples are then analysed by chemical, mechanical, rheological and thermal properties analyses. It is aimed that the data generated will support the design and sizing of mechanical pit-emptying devices, transportation and processing systems for the excavated sludge, and the design of future on-site sanitation facilities. Preliminary results and the plan for future work are presented and discussed.

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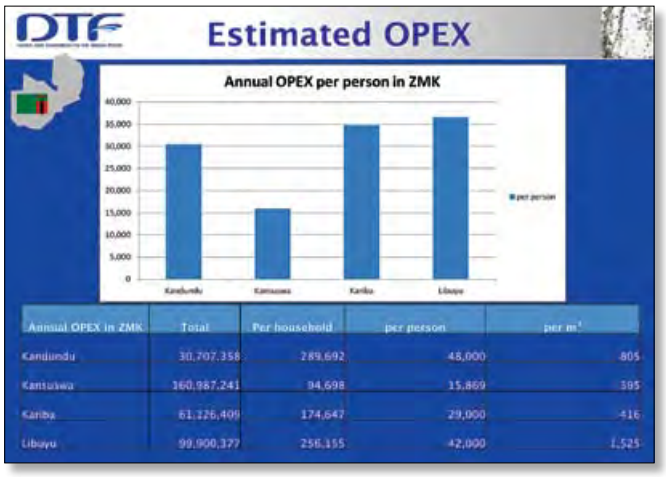
Wednesday 31 October 2012 / Session B8: Breakaway 1

Faecal sludge management at decentralised treatment systems in Zambia

S Blume * and Jackson Mulenga **

This presentation highlighted the work of the Devolution Trust Fund, in partnership with BORDA and WASAZA, who have piloted a solid free sewer approach in four Zambian sanitation projects, supplying 15 600 people with improved sanitation services in low income areas. The underlying principle of the projects is to use biogas digesters as immediate settlers/first treatment step (connecting up to 40 households per digester). This serves to reduce the solid load in the small bore sewer system that connects further to a secondary decentralised treatment step through an Anaerobic Baffled Reactor and Planted Gravel Filter or waste stabilisation pond system. Additionally, biogas is generated that will be used by 108 households. It is assumed that the projects will provide users the convenience of flush systems but will require - a rather non frequent - Faecal Sludge Management for emptying the biogas digesters (approximately once a year). The emptying and treatment service is a foreseen duty of the Commercial Water Utility or a Community Based Organisation that shall use either vacuum trucks or gulper technology, depending on resources available. The treatment of faecal sludge shall be done in appropriate treatment facilities. Reuse of stabilised sludge is envisaged through application on a nearby banana plantation for one project that applies a full DEWATS system. Altogether, waste water from approximately 3 540 people (590 households) is connected to 15 biogas digesters (ranging from 30 – 40 cubic meters volume each). With an assumed sludge accumulation rate of 60 litres per person and year, 212 400 litres of sludge are to be handled each year. A household sanitation fee shall be applied on the water bill to finance operation and maintenance and faecal sludge management activities. Initial analysis indicates that full operating costs can be recovered applying a sanitation tariff which is between 25% and 78% of the water tariff.



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Pilot Project on faecal sludge management in Lusaka Zambia

Christopher Kellner*, Mwanza Nchalu**

This presentation discussed the work of the WSUP (Water and Sanitation for the Urban Poor) in cooperation with the funder *Stone Family*, who have linked up with the Water and Sanitation Association of Zambia *(WASAZA)* and Lusaka Water and Sewerage Company *(LWSC)* to implement a *Faecal Sludge Management Project* in three low cost area townships around Lusaka. The sanitation conditions in peri-urban townships in Zambia are problematic. The population density increases rapidly and toilets contaminate the underground water, while many people fetch their water from shallow wells on a daily basis. Consequently, in the rainy season there are regular outbreaks of cholera and typhoid. Linking the areas to the sewer network of the town, for instance in the case of Lusaka's outskirts, is not affordable. Partially unplanned structures, the high level of rock outcrops and the poor general drainage are the reasons for this. In respect of the challenges regarding the achievement of the Millennium Development Goals in the sub sector of sanitation, donors are communicating their willingness to support sanitation measures. It is the objective of the project to identify and test methods of faecal sludge management which are economically viable. This can be achieved if all together;

- The emptying service fee.
- The sales of the biogas generated in the (enlarged) transfer station, and
- The sales of the dried digested slurry from drying beds as fertilizer, generate cost covering benefits.

The construction of the pilot installation started in August 2012.

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From waste to resource - research on FS drying beds in Dakar, Senegal (Dar - de Dechets à Resources)

Seydou Niang*, Amadou Gueye**, Alsane Seck**, Hamath Dione**, Mamadou Sonko**, Jean Birane Gning**, Mbaye Mbéguéré***, Linda Strande****

In Senegal, to reach the millennium development goals in 2015 for sanitation, targets are to achieve 92 000 connections to sewerage systems and an additional 453 000 onsite systems in both rural and urban areas. Achieving this goal will also greatly increase the volume of sludge that needs to be managed. To ensure these goals are sustainably implemented, plans for sludge end-use or disposal must be undertaken long before the systems become operational. Current strategies that are being researched in Dakar by the DAR research programme include the use of sludge as a fuel in industry, and as a medium to grow fodder plants. Creating added value during the treatment process is expected to help reduce the cost of emptying, transport, and treatment, providing a financial driver to help ensure that the entire faecal sludge service chain is functioning. Initial results from using locally built ventilated greenhouses to enhance drying are promising. Over 14 days, in drying beds covered with greenhouses, 60% dryness was achieved for a load of 300 kgTS/m^2/Y loads, while during the same time, non-covered beds reached only 40% dryness. Current trials for growing fodder with faecal sludge have been focused on the optimal selection of local plants. Seven plants that are commonly used for fodder in Senegal were submitted to 12m^3/m^2/Y of raw faecal sludge. Five of them grew well; *Echinochloa pyramidalis, Echinochloa crus-galli, Paspalidium geminatum, Echinochloa Colona, Paspalum vaginatu,* while two of them; Imperata cylindrica, Eleusine indica did not grow well at all. Currently, tests are being conducted to select three species that show the most potential for use in planted drying beds, and then to further optimise this application.

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Market demand for end-products of faecal sludge treatment in Kampala, Accra, and Dakar

S Semiyaga*, S Diener**, CB Niwagaba*, JB Gning***, JE Ennin****, L Strande**

This presentation highlighted a model that recognises resources in FS, and can provide a profit motive for on-going collection and transport to treatment facilities. The aim of the study was to identify the market demand for innovative end-products in Kampala (Uganda), Accra (Ghana) and Dakar (Senegal). Sanitation systems throughout urban areas of Sub-Saharan Africa are characterised by poorly maintained on-site sanitation systems, dysfunctional faecal sludge (FS) collection and transport, and disposal of untreated or inadequately treated FS directly into the environment. The situation could be improved through the development and implementation of reuse-oriented value chains, changing the focus of FS management from that of disposal problems to generators of valuable end-products. An iterative method for selecting interview partners was chosen. This included the following approaches: i) focus group discussions, ii) open-ended, semi-structured interviews, and iii) spontaneous enquiries and visits of relevant enterprises/entrepreneurs. The identified market demand in the three cities include: (i) dried FS as alternative fuel in industries; (ii) dewatered FS as a feed source for black soldier fly larvae to produce animal protein; (iii) FS as a feedstock for biogas production; and (iv) treated FS as a soil conditioner in agriculture. Industrial use of FS as a fuel was most promising in Kampala, where 60% of industries are using solid fuels (e.g. wood), compared to Dakar and Accra where the majority of industries are using electricity and liquid fuels (e.g. diesel). In all three cities, treated sludge is already utilised in some form: FS as a soil conditioner and sewage sludge as bio-digester feedstock in Dakar; FS as a soil conditioner in Accra; and treated sewage sludge as a soil conditioner by farmers and landscapers in Kampala. The identified markets provide many promising opportunities for the future sale and resource recovery of FS treatment end-products.

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Choosing an appropriate sanitation system for citywide sanitation for small towns in India

Meera Mehta*, Dinesh Mehta* and Chandan Chawla**

This presentation shared baseline assessment across the sanitation value chain in four smaller towns in Maharashtra (India) and provided an assessment of low cost technologies and solutions for decentralised sanitation service provision in these towns. The growing urban population in India already accounts for 31.16% of the total population and has been calling for increased investments in infrastructure to sustain the GDP growth. The larger urban centres have been the driving forces in economic and social development, and have received the necessary attention in terms of investments from central and state programmes, technology support and interests from the private sector to build and operate urban infrastructure. In the coming years, urban infrastructure provision in India is going to be challenged predominantly by the requirements of smaller towns. These towns are visibly deficient in the quality of sanitation infrastructure and service delivery. Addressing the needs of these towns will prove a challenge to conventional methods which are high on capital and operating costs. Innovations will be needed to achieve operation, management and financing of sanitation services with the limited resources available. At the same time it will be necessary to provide affordable services in slums to achieve goals advocated by the National Urban Sanitation policy (2008) of ensuring universal access of services and eliminating open defecation prevalent in these towns.

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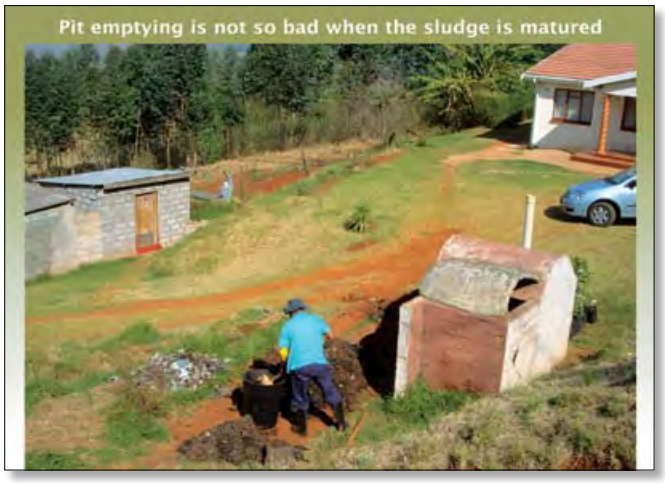
Wednesday 31 October 2012 / Session C7: Breakaway 2

In search of the ideal pit emptying technology

D Still*; M O'Riordan**; A McBride**

Over the last four years Partners in Development, with assistance from Engineers without Borders UK volunteers, has been brainstorming, building and testing a series of Pit Emptying Technologies, or PETS. This presentation provided an insight into some of these technologies. Who would want to be a pit latrine emptier, and if you were, how would you get the job done? That would depend on what the customer was prepared to pay, where the sludge was going to be disposed, the accessibility of the site, and the nature of the sludge itself. Vacuum tankers of various sizes are suitable when the sludge is not too dense or dry, when it is possible to park the truck close enough to the pit for the suction to work, and when there is enough money available to pay for the tanker operation and maintenance. In reality one of these prerequisites is often not met, and then the job gets done manually using buckets on ropes, scoops on poles, long handled rakes and shovels, or even with ordinary shovels. Is it possible to develop tools and small machines which would make it possible for manual pit emptying to done with greater safety and dignity? Over the past two decades a variety of machines have been developed and tested, including the MAPET, the Vacutug and the Gulper. Each of these works well in certain circumstances. Some of the PETs have included a chain and scoop device called a Gobbler, a motorised auger called the PSA (for Pit sludge auger), and two portable vacuum pumping machines, the Nanovac and the eVac, all of which seemed like a good idea at the time. Of these the eVac, an electrically powered vane pump driven plug and gulp vacuum system shows the most promise, but only on wetter sludges. If the sludge is dry and dense, there is still nothing to beat a shovel for cost effectiveness and practicality. However, with intelligent pit design, a pit emptier's job can be made much less difficult and less hazardous.



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eThekwini pit latrine emptying programme

Dave Wilson, John Harrison

This presentation discussed the VIP emptying process with its pitfalls and the solutions to make the process an environmentally improved process which is also economically viable. The servicing of VIP latrines in urban areas in the developing world is fraught with challenges, particularly in South Africa where some additional unforeseen challenges have arisen due to inexperience in this field of work. In 2005 the eThekwini Council passed a resolution whereby each VIP in the Metro would receive one free evacuation on a 5 yearly cycle. Water and Sanitation (EWS), the municipal entity responsible for providing sanitation services to Durban and its surrounds, in 2006 embarked on a pilot project to find the most suitable method for emptying VIPs. This culminated in the awarding of a contract to empty 35 000 VIP's over a three year period. Many valuable lessons were learnt during this contract. There were, however, five major challenges, namely 'Space and Access', 'Pathogens', 'Excess water', 'Detritus' and 'Disposal methods'. The most significant hurdle was the disposal of the sludge which, due to the sticky texture of the sludge along with the detritus, posed some serious challenges. These lessons resulted in the piloting of a new technology for the disposal of sludge, which results in a better environmental solution and also addresses some socio-economic challenges.

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Social franchising principles do work: the business approach to removal and disposal of faecal sludge - from pilot to scale

K Wall* , O Ive **, J Bhagwan***, F Kirwan ****

Studies undertaken by the CSIR and WRC have found that the concept of social franchising partnerships for the routine maintenance of infrastructure could alleviate and address many challenges in the management of water services. A pilot project, under way in the Eastern Cape since 2009, has drawn to a successful conclusion. This provided selected infrastructure maintenance services to approximately 400 schools in the Butterworth education district. Half a dozen franchisee micro-businesses were created, and of the order of three dozen previously unemployed people were taught workplace skills. Irish Aid funded the concept development, but the franchisees were paid from the normal Department of Education (DoE) schools operation and maintenance budgets. Despite difficulties arising directly from DoE inefficiencies, the pilot project has proven the value of social franchising partnerships for this kind of work - the DoE now has a model it can roll out to the rest of the more than 4000 schools across the Eastern Cape, which have a similar type of infrastructure. Many opportunities lie in applying the same approach to other operation and/or maintenance activities within the water and sanitation services delivery chain. The time is now ripe to further develop the concept so that it can move up the technology ladder, expanding its range of competencies beyond its current comfort zone.

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Demonstrating the effectiveness of social franchising principles: the emptying of household vips

K Wall*, O Ive **, J Bhagwan***, F Kirwan****,
W Birkholz*****, N Lupuwana******, E Shaylor *****

This presentation described the methods and results in removal and disposal of faecal sludge. Having viewed the social franchising partnerships pilot programme that successfully serviced sanitation facilities at 400 schools in the Butterworth District of the Eastern Cape, the Amathole District Municipality (ADM) expressed interest in exploring how well the partnership model could empty household pit latrines in its jurisdiction. The impact and effectiveness of the model was demonstrated through the emptying, by five franchisees over a period of only six weeks, of the contents of 400 household VIPs, and the safe disposal of these contents. Not unexpectedly, the amount of effort involved in this work - including time, training required, equipment required, and ingenuity - varied enormously. The main variables included the type of top structure, the nature of the pit contents, whether there was or was not broad consistency of type and contents in an area, distances (between pits, from home base to work site, from pits to disposal site, from location of specialised equipment to work site), logistical delays (e.g. non arrival of equipment), and bureaucratic hold-ups (especially payment delays). But the biggest single influence on cost was continuity of work, or lack thereof.

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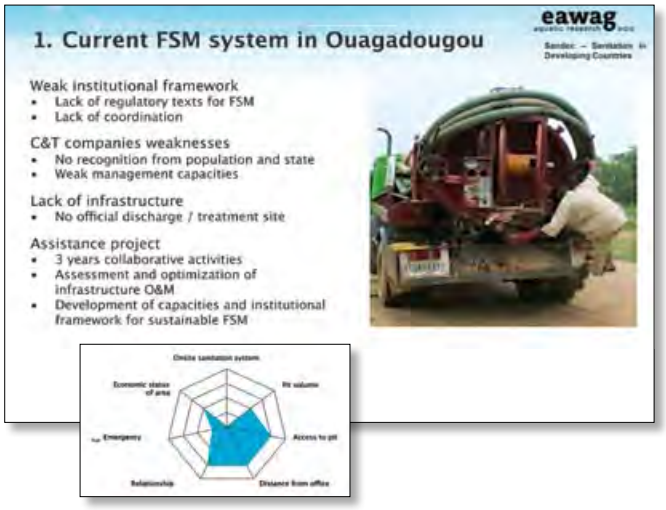
*****Impilo Yabantu, East London. ****** franchisee of Impilo Yabantu, Butterworth.*

Wednesday 31 October 2012 / Session C8: Breakaway 2

Viability of faecal sludge collection and transport in Ouagadougou, Burkina Faso

Magalie Bassan*(1), Tetouehaki Tchonda(1), Francesca Gambazzi(1), Linda Strande(1)

ONEA (the National Water and Sanitation Utility of Burkina Faso) and Sandec/Eawag have developed an institutional framework for Faecal Sludge Management (FSM) in Burkina Faso. Meetings and workshops were held between 2010 and 2012 to build trusting relationships with collection and transport (C&T) companies and other local stakeholders, to assess working conditions, improve management capacities, and strengthen the C&T professional association. Results included capacity strengthening of local stakeholders, and formalising the relationship between C&T companies and the FS management sector. The financial viability of C&T companies was assessed based on interviews with one government-owned and three private companies. Service fee structures were found to be independent of actual operating costs, with a mean service fee of 15000 FCFA (23 Euro) based on different parameters (i.e. difficulty to access the onsite systems, transportation distance, number of trips needed to complete the emptying operation). The smaller companies with one or two trucks were not financially sustainable. A handbook was designed to promote hygiene, safe operating conditions, and financial management for C&T, and was used in a training session. The training and workshops provided an opportunity to optimise financial sustainability of the businesses, and the quality of service that is provided.



Contact details: *Magalie Bassan*(1), Tetouehaki Tchonda(1), Francesca Gambazzi(1), Linda Strande(1). (1)Eawag (Swiss Federal Institute of Aquatic Science & Technology). Sandec (Department of Water & Sanitation in Developing Countries). Eawag, PO Box 611, 8600 Dübendorf, Switzerland; www.sandec.ch*
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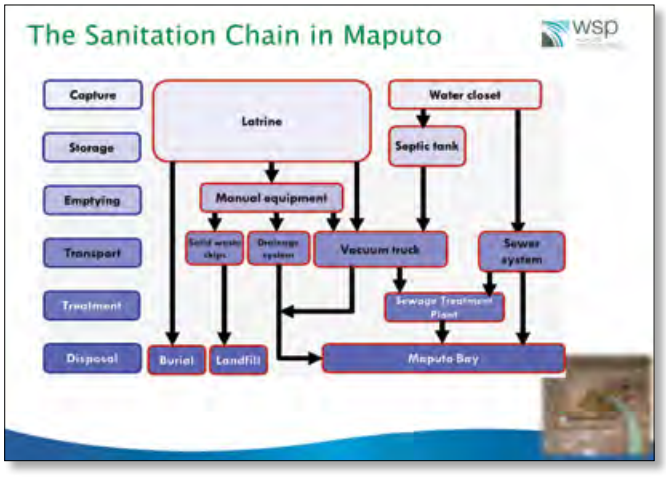
Building Blocks for Effective Faecal sludge management in peri-urban Areas: The role of small-scale independent providers (SSIP) in Maputo.

Odete Muxímpua*, Peter Hawkins*

This presentation analysed the role of the private sector in improving sludge management in peri-urban areas, looking at the options developed and implemented so far, as well as their potential for scaling up in different socio-economic environments. Faecal Sludge Management (FSM) is a major challenge for peri-urban sanitation in the majority of Sub-Saharan African cities. With more than 80% of its population living in peri-urban settlements, and relying on on-site sanitation facilities, Maputo produces on average 150m^3/day of sludge. Most of the sludge from peri-urban latrines is buried in the yard, or dumped in solid waste skips and drainage channels, whilst only a small portion is delivered to the municipal sewage treatment plant. Emptying services are mainly undertaken by SSIPs, ranging from bucket emptiers, to small enterprises which combine emptying with transportation to the treatment plant. Having identified the potential role of the private sector in improving sludge management in peri-urban areas, Maputo Municipality partners are developing support programs to improve sludge management in the city. Findings from the study show a great potential for SSIPs to provide adequate FSM services in the peri-urban settlements. There are however some challenges regarding the quality of sanitation facilities to be emptied, transfer processes, and financing for SSIPs. The study therefore recommends that an integrated approach should be implemented, where all the actors work in a coordinated manner to overcome the challenges identified.



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Hygienic pit emptying with low cost auger pump

Robert C Borden, Tate W Rogers, Francis de los Reyes III

Pit latrines and septic tanks can potentially provide a safe and affordable method for temporary storage of excreta. However, these devices must be periodically emptied. Traditional tanker trucks with vacuum pumps cannot access pits along narrow roads and alleys and is often prohibitively expensive. A screw pump for rapidly and hygienically emptying latrines and cess pits has been developed from a standard gasoline powered earth auger, PVC pipe, plastic screw flights, and plastic coupling. The machine operates by rotating the screw flights and lifting the waste up the pipe, out through a tee fitting, and into a container or drum for off-site transport. Once the pit is empty, the user would transport the drums by hand-truck and/or a small scooter powered cart to the disposal facility. The pump prototype weighs between 20-30 kg depending on the configuration and can be operated by one person. The screw pump will come with several different lengths of pipe and screw auger allowing use on different depth latrines. The total cost to assemble the unit in the US is approximately $700 and all needed components are readily available throughout the world. Use of this equipment will dramatically improve productivity, allowing a typical latrine to be emptied for less than $5 per pit and allowing access to pits that cannot be accessed by traditional tankers. The current design is capable of lifting simulated waste up to 3 m vertically from the bottom of a pit at flow rates up to 50 l/min allowing a pit to be emptied in a few minutes. The screw pump is most effective with high viscosity liquids and semi-solids, but is less effective with low viscosity fluids (e.g. water) so it will leave the most liquid portion of the waste behind in the pit. A video will be shown of the auger in operation. Experimental results will be presented illustrating the relationship between auger length, rotation speed, viscosity, and flowrate.

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Physical characterisation of pit latrine sludge

JT Radford

This presentation highlighted the development of the development of the portable penetrometer, a man-portable device to physically characterise pit latrine sludge, which measures the in-situ shear strength of the sludge in the pit. It is estimated that half of the world's urban population, totalling some 3 billion people, will live in informal settlements or "slums" by 2030. The provision of affordable urban sanitation presents a unique set of challenges as the lack of space and resources to construct new latrines makes it necessary to empty existing pits, which is typically done manually with significant health risks for the emptiers. Various mechanised technologies have therefore been developed to facilitate pit emptying, and these are currently either tested on faecal sludge, with associated health and safety risks, or on an 'ad-hoc' simulant that approximately replicates the behaviour of faecal sludge, in the opinion of the tester. In both cases there is very limited information available on the physical properties of the sludge, which can range from a watery consistency in some pour flush latrines to the strong soil found in many alternating ventilated improved pit latrines. This makes it difficult to evaluate the effect of changes to a design, or to compare the performance of different technologies produced by different firms in different countries. The current machine produces continuous profiles of sheer strength with depth and is capable of testing to approximately 2.5m below the slab. The portable penetrometer was manufactured and tested in the UK, before being used to profile approximately 30 pits in Kampala, Uganda. That data is compared to the literature on the physical properties of faecal sludge, and is found to significantly extend the measured strength range with a maximum value approximately four times higher than previously reported. The effect of physical remoulding is identified through comparison of data from undisturbed and remoulded strength tests, and highlights the potential to increase the 'pumpability' of faecal sludge through in-pit fluidisation.

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Working small sanitation enterprise for faecal sludge management in peri-urban Maputo: The experience of WSUP

Amaka Godfrey*, Carla Costa**, VR Baghirathan***.

This presentation discussed the experience of the Water and Sanitation for the Urban Poor (WSUP) FSM pilot project in the Maputo bairro of Maxaquene A. Sanitation in the peri-urban areas of Maputo is generally poor, with the pit latrine being the most widespread type of facility used by households. Faecal sludge management (FSM) is ineffective and inadequate, often worsening the sanitation conditions. The widespread lack of appropriate toilets, poor drainage system, unplanned housing, and high water table make the management of pit emptying and sludge disposal an almost impossible task. Many latrines are poorly constructed and prone to collapse if emptied completely. Their design also allows groundwater and/or surface water ingress, which contributes to the problem, allowing them to fill up quickly. Past and present latrine construction projects have concentrated on building latrines without considering how they will be emptied. The pilot began in May 2011 in collaboration with the Small-Scale Independent Provider (SSIP) UGSM (Uaiene Gama Services Maputo). WSUP started discussions with UGSM to provide pit emptying services in May 2011 using a 2-staged pilot:

Stage 1: Improved pit emptying services using manual and mechanised pumps.

Stage 2: Latrine improvement with low-interest credit facility.

To ensure sustainability a joint business plan was drawn up between the WSUP and UGSM with defined repayment amounts and periods.

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Sponsors and Partners

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Department of Science and Technology
http://www.dst.gov.za

Envirosan Sanitation Solutions cc
http://envirosan.co.za/about-us/

eThekwini Municipality
http://www. durban.gov.za

International Water Association
http://www.iwahq.org/2l/about-iwa.html

Irish Aid
http://www.irishaid.gov.ie/about.html

Sustainable Sanitation Design (SuSan)
www.susan-design.org

University of KwaZulu-Natal
http://www.ukzn.ac.za/

Water and Sanitation for all in Africa - WSA
http://www.wsafrica.org/welcome/who-we-are.aspx

Water Research Commission
http://www.wrc.org.za

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